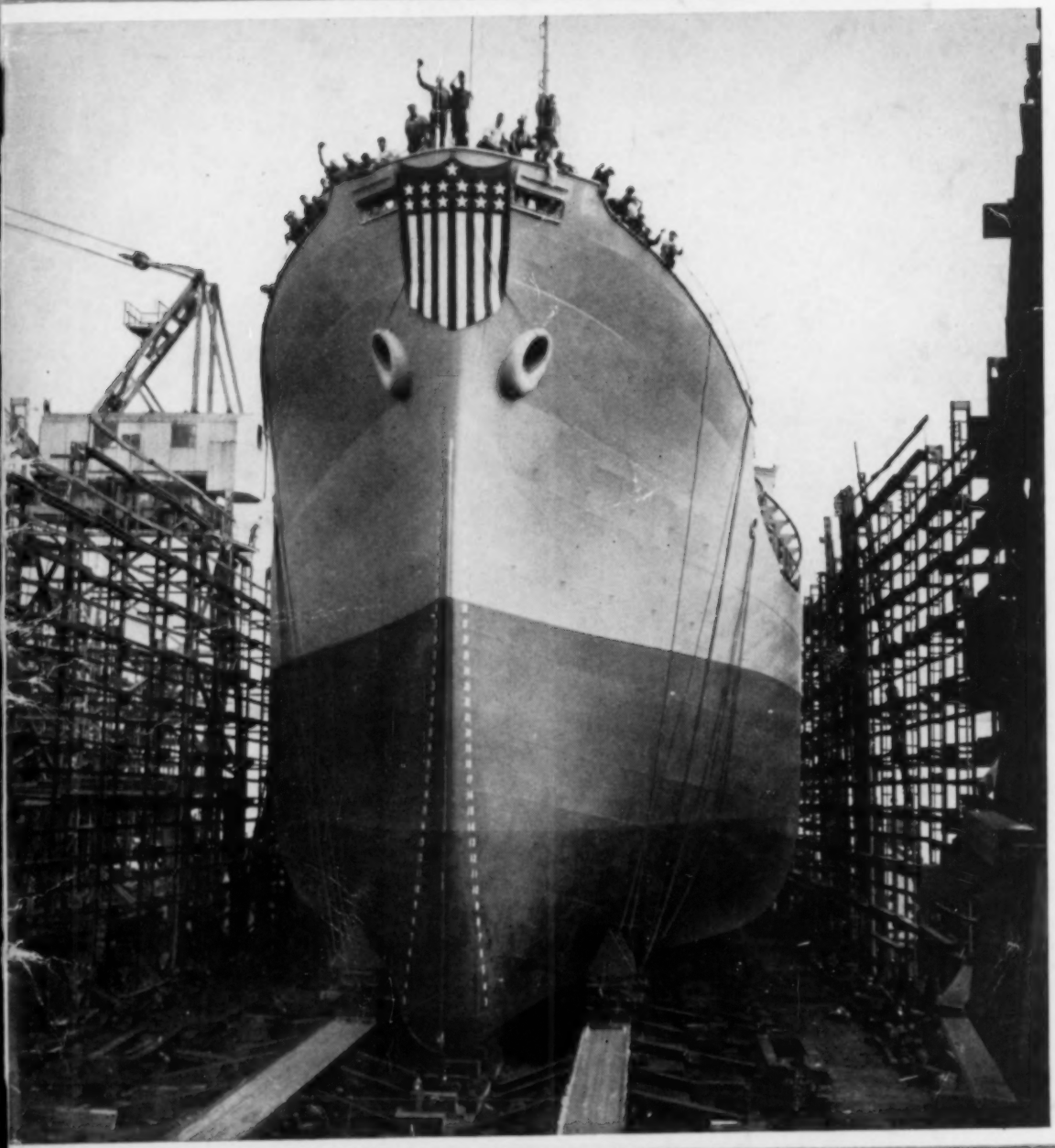
Compressed Air Magazine

FEBRUARY 1945



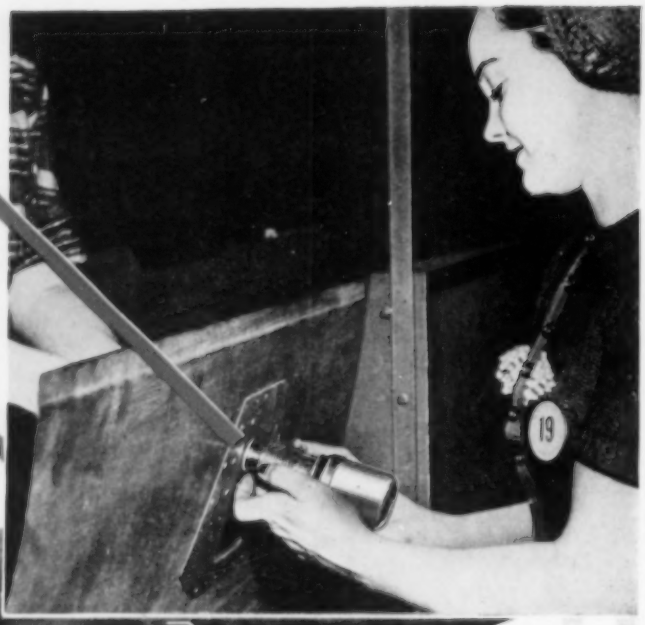
A TANKER GOES DOWN THE WAYS

Six or more of these ships are built each month at Sun Shipyard.

VOLUME 50 • NUMBER 2

NEW YORK • LONDON

A LIGHT TAP OR A SLUGGING BLOW



. . . EITHER JOB CAN BE DONE BEST WITH

AIR TOOLS

The I-R line of riveting hammers will handle rivets from 1/8" to 1 1/4" diameter . . . a range sufficient to handle practically all riveting jobs.

The practice of making enough sizes of each tool to handle various operations has long been a standard I-R policy. Thus, when it comes to riveting, chipping, drilling, reaming, nut running, grinding, digging, tamping, etc., you will find a wide selection from which to choose.

The operating features of I-R Air Tools have made them extremely popular with the men and women of industry. When you get an I-R Air Tool, you get—light weight—power regulation—durability—more power per pound of weight—trouble-free service and safety. In addition, each tool is backed by Ingersoll-Rand service, available in all principal cities.

Let one of our men assist you in selecting the proper tool for the job.

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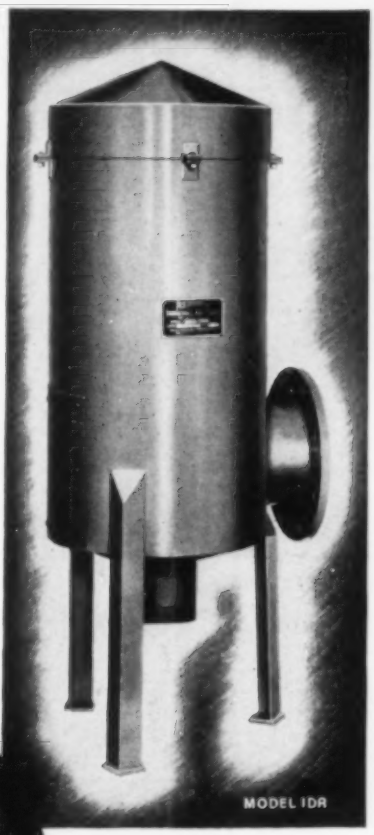
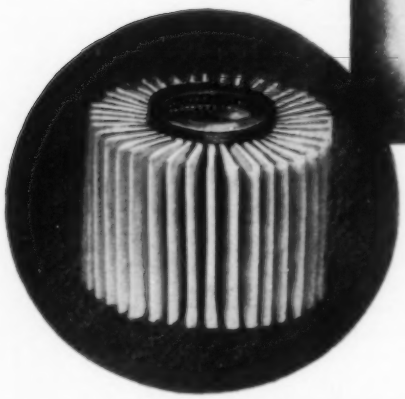
COMPRESSORS • TURBO-BLOWERS • ROCK DRILLS • AIR TOOLS • CENTRIFUGAL PUMPS • CONDENSERS • OIL AND GAS ENGINES

new STAYNEW Intake Air Filter





EXCLUSIVE RADIAL FIN CONSTRUCTION PROVIDES:

- *More Filtering Area
- *Greater Efficiency
- *Less Resistance
- *Less Frequent Servicing

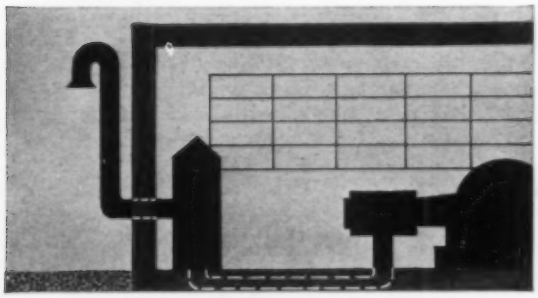
ALL THE CONVENIENCE OF GROUND LEVEL INSTALLATION

ALL THE EFFICIENCY OF HIGH LEVEL AIR INTAKE

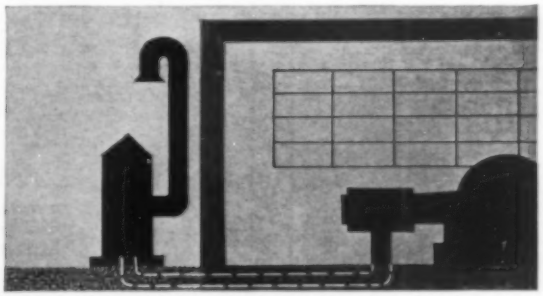
NOW you can equip compressors and internal combustion engines with a Staynew filter providing all the recognized advantages of the famous Protectomotor line . . . *plus* an exclusive combination of two new features.

The new filter, Staynew Model IDR, or IDRS (Silencer), is so constructed that *installation and servicing can be effected at ground level* (right in the engine room itself if preferred), and the *actual air intake located at the most suitable point.*

Models available with solid base for installation when compressor or engine intake is below floor level.



Model IDR INSIDE Engine Room



Model IDR OUTSIDE Engine Room

Engineering Data on request STAYNEW PROTECTOMOTOR FILTERS Representatives in Principal Cities

DOLLINGER CORPORATION

(Formerly Staynew Filter Corporation)

7 Centre Pk.

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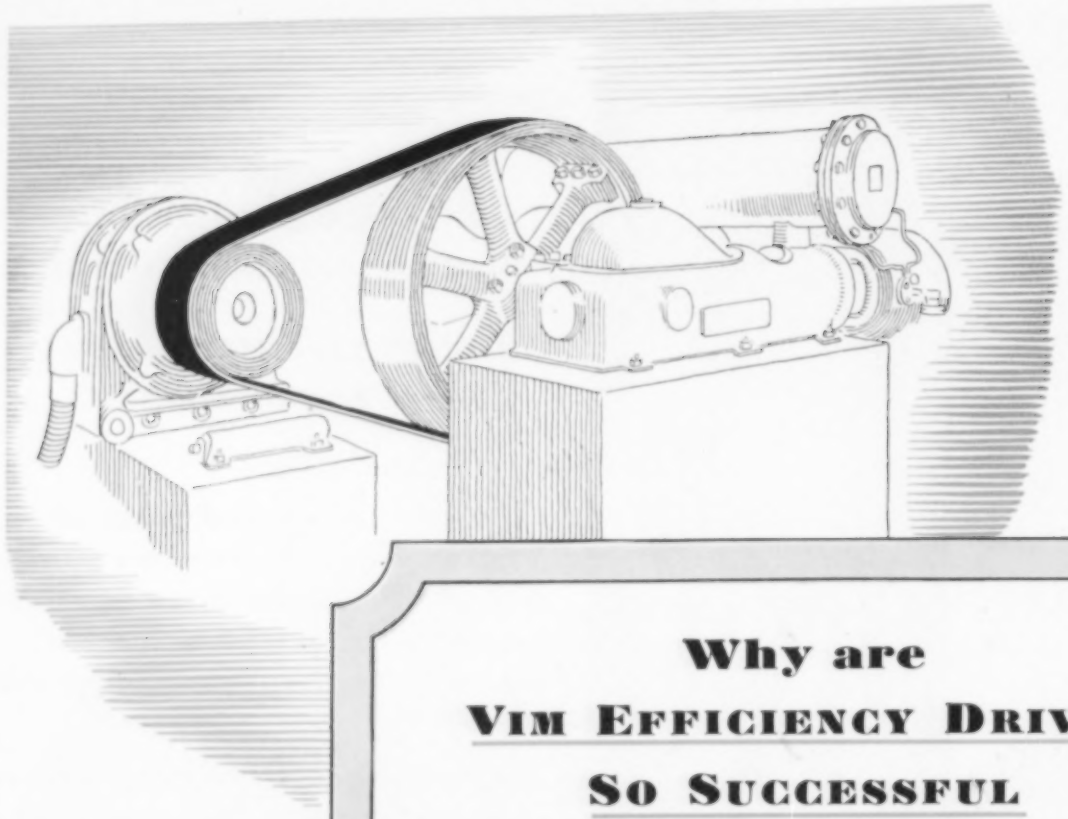


Why are VIM EFFICIENCY DRIVES SO SUCCESSFUL on compressors?

Driving a compressor so it will supply all the air you need, when you need it, is a tough job . . . but a "natural" for VIM Tred Leather, which likes tough assignments.

Team up this superior belt with a pivoted motor base to maintain correct uniform tension, and you have a combination that can't be beat. Here's why:

First, you get longer belt life, and lower maintenance cost; that's provable. Then, you'll have less strain on motor and compressor bearings because the drive absorbs shock loads. There'll be less slippage when starting, and a quieter running job.

No special-shaped pulleys are required. Belts can be made endless on the job. No need for frequent take-ups to compensate for initial stretch.

You'll get A-1 results with short centers and high pulley ratios. Space is saved . . . less belt required.

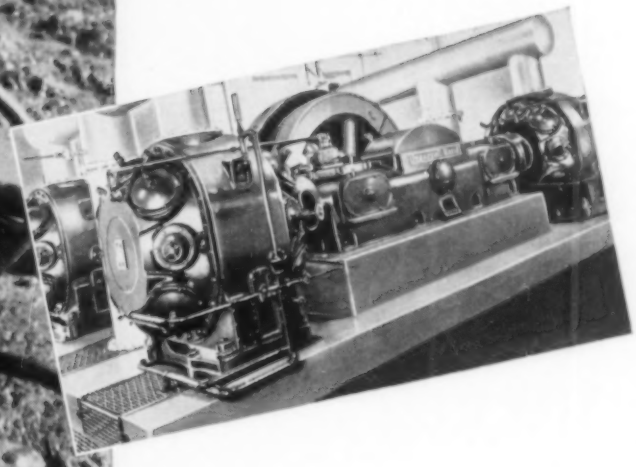
The Houghton Man can give you further advantages, and go more fully into those cited above. Ask him to quote on your belting needs—compressors or all through the shop. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia, and all principal cities.

Houghton's

VIM TRED

Leather Belting

SCRUB TEAM



THE USES of compressed air in war and peace are virtually unlimited. Mining and construction are everywhere speeded by air-powered drills, grinders, riveting hammers, chippers, hoists and other tools. In the picture, taken during the building of Grand Coulee Dam, you see still another use . . . compressed air teamed up with water to scrub a concrete surface.

Successful use of compressed air in industry depends on smooth functioning of both air compressors and tools . . . immeasurably aided by effective lubrication . . . Texaco.

Texaco Alcaid, Algol or *Ursa Oils* in air compressors, for instance, assure wide-opening, tight-closing valves, free piston rings, open ports, clear lines, continuous air supply. They also assure maximum service life between overhauls, fewer repairs and replacements. Their use in air compressors is world-wide.

Texaco lubricants have proved so effective in service they are definitely preferred in many fields, a few of which are listed at the right.

Texaco Lubrication Engineering Service is available to you through more than 2300 Texaco distributing points in the 48 States.

☆ ☆ ☆

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

THEY PREFER TEXACO

★ *More stationary Diesel horsepower in the U. S. is lubricated with Texaco than with any other brand.*

★ *More Diesel horsepower on streamlined trains in the U. S. is lubricated with Texaco than with all other brands combined.*

★ *More locomotives and railroad cars in the U. S. are lubricated with Texaco than with any other brand.*

★ *More revenue airline miles in the U. S. are flown with Texaco than with any other brand.*

★ *More buses, more bus lines and more bus-miles are lubricated with Texaco than with any other brand.*

TEXACO

TEXACO Lubricants

FOR ALL AIR COMPRESSORS AND TOOLS

TUNE IN THE TEXACO STAR THEATRE WITH JAMES MELTON SUNDAY NIGHTS ★ METROPOLITAN OPERA BROADCASTS SATURDAY AFTERNOONS

Save MAINTENANCE TIME

with
WALWORTH
FIG. 709
Saddle Gate
VALVE

Bronze
STEM
STEM NUT
STUFFING NUT
GLAND
BONNET BUSHING
WEDGE
SEAT RING

THE *Iron Valve* WITH *Bronze* WHERE IT'S NEEDED

If you want to reduce valve maintenance time on lines where frequent cleaning and inspection are required — specify Walworth Fig. 709, the bronze-mounted Iron Body Saddle Style Wedge Gate Valve.

Easy to take apart because of its U-bolt body-to-bonnet connection, this valve permits quick inspection, easier cleaning, and rapid re-assembly, and can be re-packed under pressure in either the open or closed position. It is recommended for general use on steam, gas, gasoline, water, oil, and process lines, and is especially suited for lines carrying sludge, fluids of high viscosity, or mixtures which might have a tendency to clog under the disc or between the valve seats.

Walworth Fig. 709 is made with bronze wedge, seat rings, stuffing nut, gland, bonnet bushing, stem and stem nut. The bonnet and body are made of cast iron. Two drain holes located inside the bonnet permit the line fluid to drain off when the valve is open, thus eliminating the danger of serious damage due to freezing. This valve is furnished with either screwed or flanged ends, in sizes from ¼" to 4".

All Iron Valve

For services where line fluids are corrosive to bronze trim, Walworth offers Fig. 711, an iron body valve which has malleable iron wedge disc and stuffing nut, and steel gland and rising stem. This valve is available in sizes from ¼" to 4" (Screwed), and 1" to 4" (Flanged).

For further information on these Walworth Valves — and details on Walworth's complete line of valves and fittings — write on your company letterhead for a free copy of Catalog 42.

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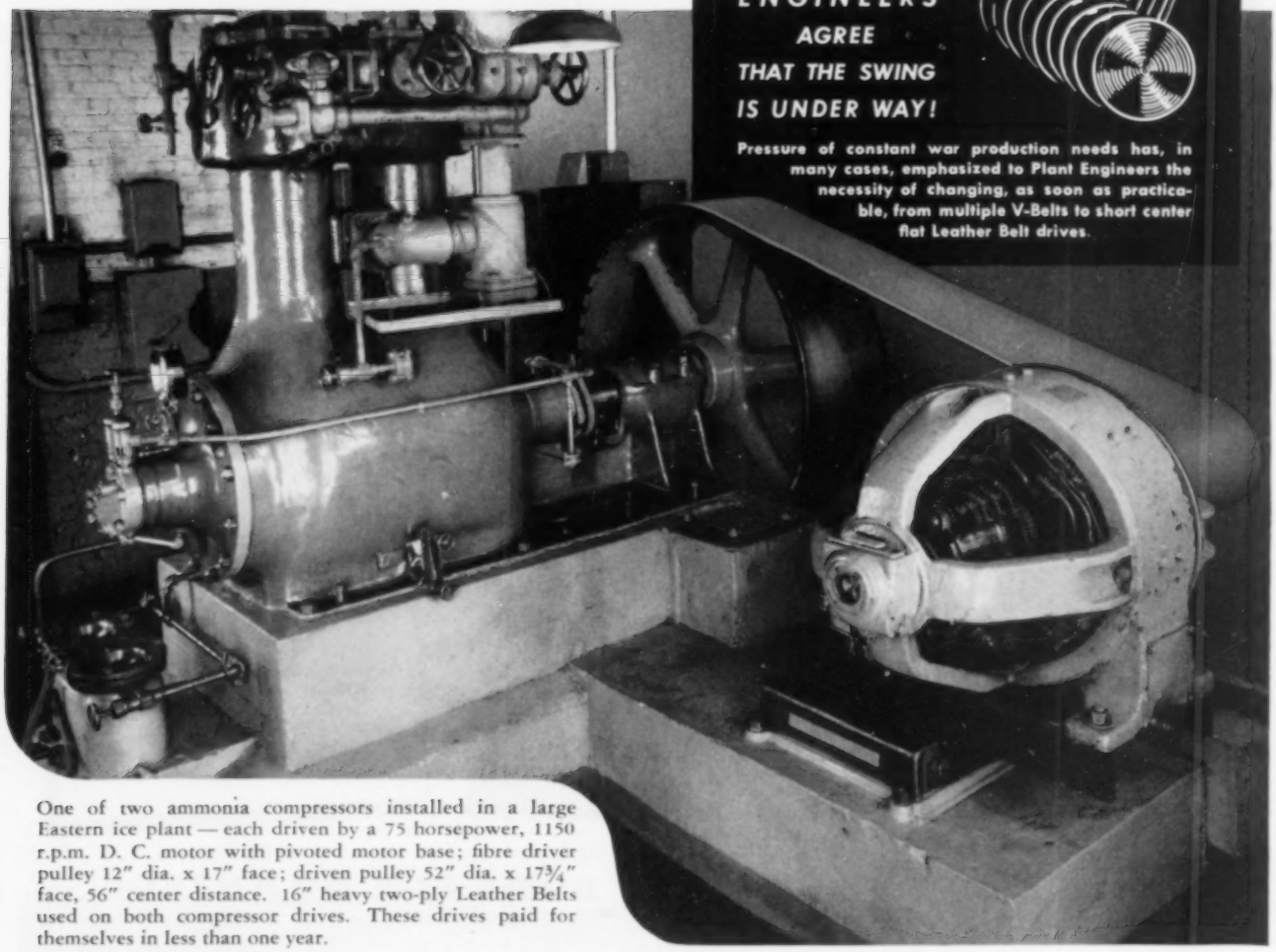
valves AND fittings
60 EAST 42nd STREET, NEW YORK 17, N. Y.

ONLY *Leather Belting* CAN DO THIS JOB PROPERLY

"INDUSTRY LEARNS BEST FROM EXPERIENCE"



ENGINEERS AGREE THAT THE SWING IS UNDER WAY!

Pressure of constant war production needs has, in many cases, emphasized to Plant Engineers the necessity of changing, as soon as practicable, from multiple V-Belts to short center flat Leather Belt drives.

One of two ammonia compressors installed in a large Eastern ice plant — each driven by a 75 horsepower, 1150 r.p.m. D. C. motor with pivoted motor base; fibre driver pulley 12″ dia. x 17″ face; driven pulley 52″ dia. x 17¾″ face, 56″ center distance. 16″ heavy two-ply Leather Belts used on both compressor drives. These drives paid for themselves in less than one year.

ANOTHER Proof that Leather Belting is Best for You, Too . . . A famous Eastern College, founded 1848, and having annual enrollment of over 2,000 students, had four drives in their boiler house each equipped, prior to 1939, with multiple V-Belt drives. Because of serious slippage at full load and short life of belts, all four were then changed to short center flat Leather Belt drives. The Chief Engineer at the College said: "We know now that flat Leather Belting, with pivoted motor base, when properly installed, is the most effective drive. After a full and fair trial with multiple V-Belts, we are glad that we changed to Leather Belting." . . . Remember: The pulley-gripping capacity of Leather Belting actually increases as the load is increased. Leather Belting absorbs shocks — saving wear on motor and machine bearings. You'll have fewer shutdowns with Leather Belting, and it's easy and comparatively inexpensive to install.

LEATHER BELTING IS LONG LIVED. IT CAN "TAKE IT."

AMERICAN LEATHER BELTING ASSOCIATION • 41 Park Row, NEW YORK 7, N. Y.

ROEBLING

QUESTIONS AND ANSWERS

Q Why are three or more seizings recommended to hold the end of a rope when one would keep it from unraveling?

A **With non - preformed rope it is almost impossible to hold the strands sufficiently tight with one seizing. If rope lay is lost or if any of the strands is allowed to shift from its balanced relation with respect to the others, improper rope life will very likely result.**

Q Is it necessary to use seizings on a preformed rope?

A **It is not necessary to use seizings to keep preformed rope from unlaying because all wires and strands are set to their helical forms. However, it is advisable to use seizings to prevent the strands from being forcibly unlaid and distorted when cutting or handling the rope. Naturally, preformed rope must be seized when preparing it for socketing.**

YOU CAN'T TAKE WIRE ROPE FOR GRANTED!

"SPEED" will be the order of the day in postwar construction. That's why you can't take wire rope for granted! ...why you can't depend on "just as good" rope for shovels or cranes or draglines.

And that's why you need *tough* Roebling "Blue Center" Wire Rope for *tough*, excavating and construction jobs! Its proven stamina to deliver long service... its engineering—both in our plant and on your job—assures economical operation by reducing costly shutdowns and expensive maintenance practices.

But find out for yourself how Roebling "Blue Center" Wire Rope fights fatigue and abrasion; how its extra strength and flexibility make it tops for all excavating and construction work... as well as *all* general heavy-duty jobs.

And find out, too, how Roebling engineers can help you choose the *right* rope for *every* operation. A telephone call to our nearest branch office is the first step toward greater returns from your rope-rigged equipment. Why not make it today?

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"The Ultimate in a *Mechanized Quarry*"

Loading rock at the quarry face. Payload is 15 tons. Cedar Hollow Plant of Warner Company, Devault, Pa.

EASTON overhead hoist, electrically operated by remote control, tips 15-ton loads quickly or feeds large rocks one at a time as required.

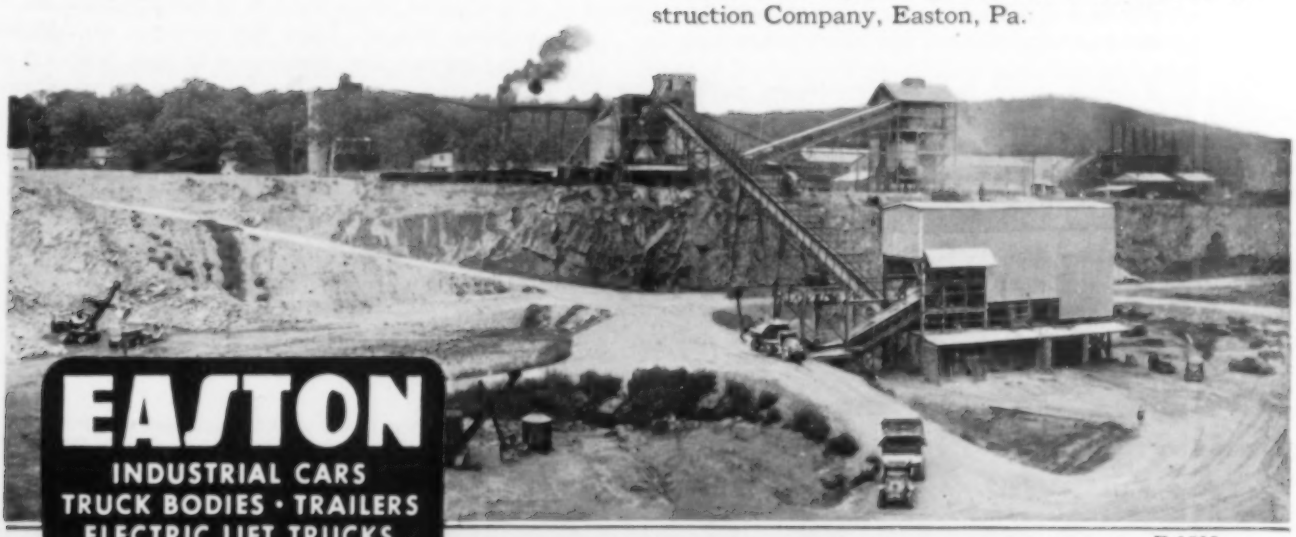
"Day after day the tractor-trailers move from quarry face to primary crusher . . . quietly, smoothly, and with no evidence of strain on either men or equipment."

"After six months' operation our records show no lost time charged to this system of conveyance . . . one which we consider to be the ultimate in a mechanized quarry operation."

This statement by Mr. Wilson, General Superintendent of the Lime Division, comes after conversion to EASTON Model TR-10 Semi-Trailers.

Semi-trailer haulage really pays dividends!

Write to: Engineering Counsel, Easton Car & Construction Company, Easton, Pa.



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INDUSTRIAL CARS
TRUCK BODIES • TRAILERS
ELECTRIC LIFT TRUCKS

B-1015

HOMO-FLEX HOSE

10

10 ADVANTAGES

1—Extreme flexibility—easy to handle
2—Resists kinking
3—Light in weight
4—Practically inseparable cover and plies—balanced homogeneous construction
5—Withstands high pressures and surges with wide margin of safety
6—Uniform inside diameter
7—Less elongation and expansion
8—Less fatigue to operator
9—More production
10—Lower ultimate cost

—a MANHATTAN Development

brings you 10 advantages important in war or peace

IN WAR—The homogeneous and extremely flexible construction achieved by MANHATTAN Strength Members of super-strength cords and the balanced, engineered method by which they are applied and inseparably combined with the FLEXLASTICS* tube and cover, together give a service impossible a few short years ago.

Every one of these advantages contributes to greater production through less fatigue to operator and to much longer hose life—therefore fewer interruptions.

Still another MANHATTAN advantage—Turnate Vulcanization—imparts added strength to Homo-Flex Hose. This process applies pressure progressively before and during vulcanization to give not only uniform inside and outside diameters, but also uniform texture and resilient strength. The distinctive spiral marking identifies Turnate Vulcanization.

IN PEACE—All these advantages will have cumulative value for you in the forthcoming competitive period. Then the multiple economies of long service life; resistance to high working pressures and surges; easy handling with less operator fatigue because of its light weight; toughness to withstand wear, abrasion and kinking; will help keep costs down and profits up.

Manhattan's Condor Brand Homo-Flex Hose is or will be available in types for the following services: Air, Water, Steam Pressing Iron, Orchard Spray, High Pressure Mine Spray, High Pressure Oil Spray.

Buy more BONDS to bring the boys down the home stretch

*The term *FLEXLASTICS* is an exclusive *MANHATTAN* trade mark. Only *MANHATTAN* can make *FLEXLASTICS*.

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THE MANHATTAN RUBBER MFG. DIVISION

of Raybestos-Manhattan, Inc.

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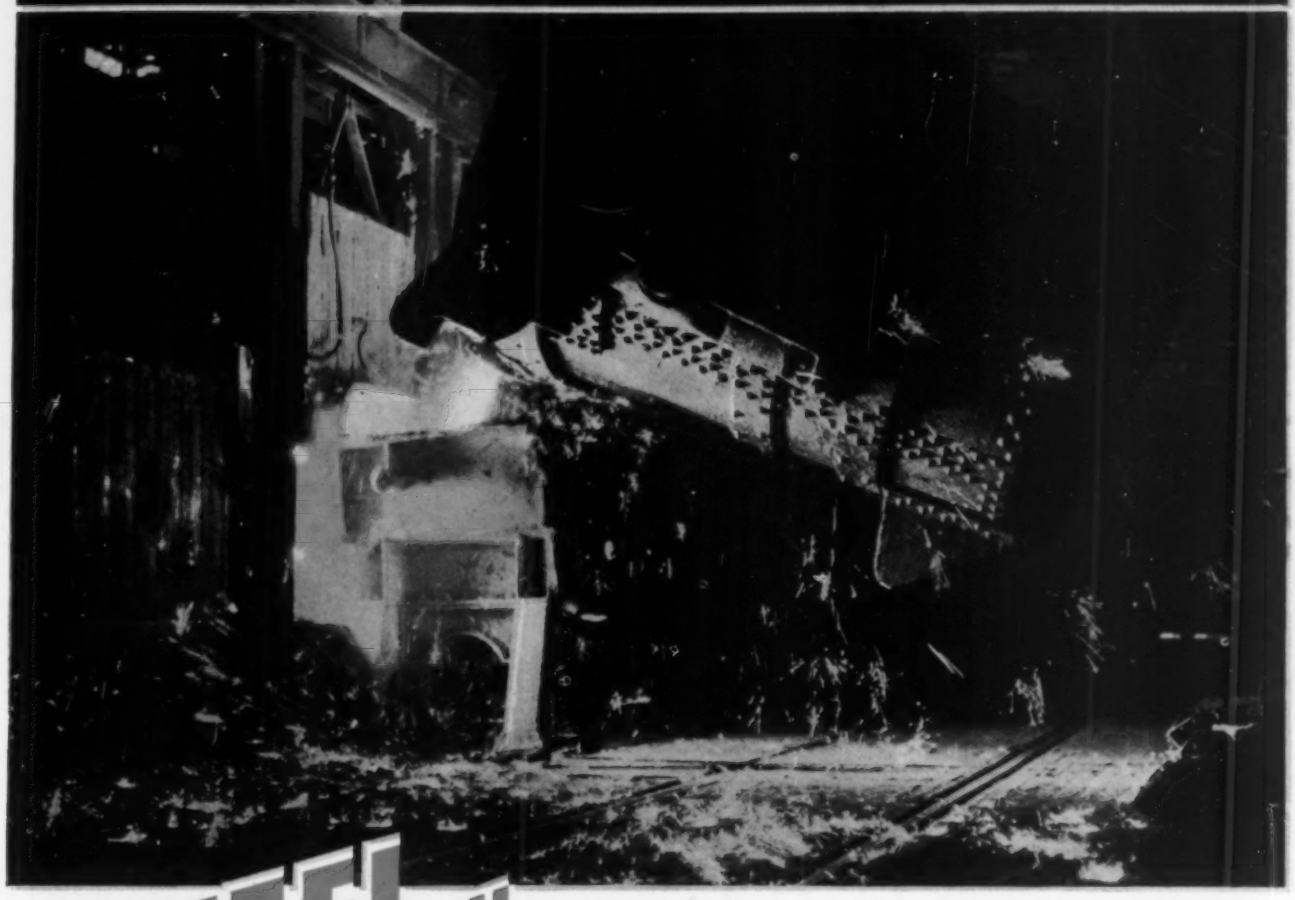
American industry flows through fairbanks valves



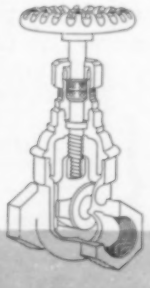
STEEL... strength of a nation

Supplier of sinew for mighty war machines, steel means business from the first flares of its fiery birth. To the clang of giant hammers shaping it to man's use, steel as a metal and as an industry is piling up a year-after-year performance record that staggers imagination.

Steel is vital to our economy in a way no other material can parallel. And in no other field is the service of valves by the thousands more important to steadily-maintained high levels of essential production.

The large quantities of Fairbanks Valves used in the steel industry afford a striking example of what we mean when we say "American Industry flows through Fairbanks Valves." This wide line of bronze and iron valves is backed by more than fifty years of frequent advances in manufacturing . . . consistent improvements in materials.

Fairbanks Catalog Number 42 gives specifications, prices. If it's not in your files now, we suggest you write today. When we send it, we'll advise you of nearest distributor.



THE fairbanks COMPANY

393 LAFAYETTE STREET, NEW YORK 3, N. Y.

320 Atlantic Avenue, Boston 10, Mass. • 15 Ferry Street, Pittsburgh 22, Pa.

ARE YOU IN A HURRY?
if so, here's help!

A production man has just compiled a book which shows how to get many a job done in a hurry without time-killing toil or elaborate equipment.

24 pages packed with facts and photographs

SHOW HOW

There you have it, the answer is COMPRESSED AIR. Every plant foreman should have a copy of this booklet — it is a clearing house of ideas for production men.

Write or phone the company or any of its branches today for your copy; it is yours for the asking.

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Please Send Us a Copy of Bulletin
"A LITTLE AIR POWER WILL DO MANY A BIG JOB"

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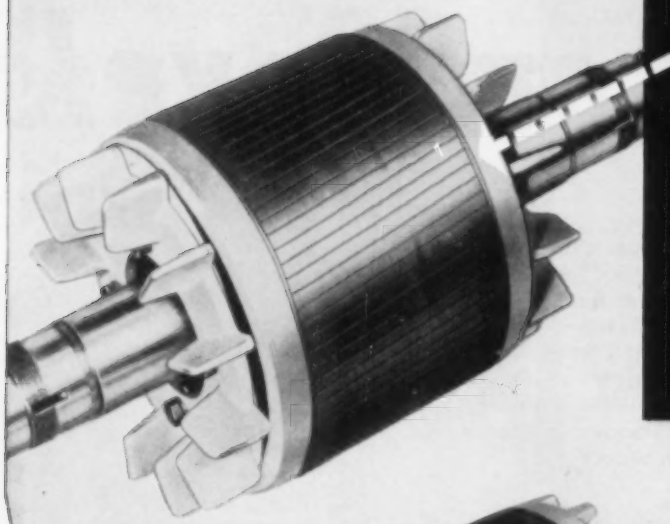
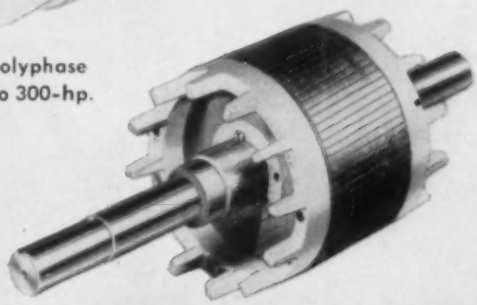
COMPRESSORS • TURBO-BLOWERS • ROCK DRILLS • AIR TOOLS • CENTRIFUGAL PUMPS • CONDENSERS • OIL AND GAS ENGINES

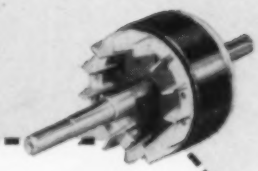
Cast Aluminum Rotor Construction GIVES LONG LIFE TO Wagner MOTORS



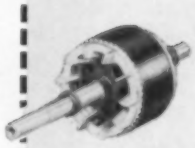
Rotor for polyphase motors 40 to 300-hp.



Rotor for polyphase motors 5 to 30-hp.



Rotor for polyphase motors 1/6 to 3-hp.



Rotor for split-phase motors 1/20 to 1/3-hp. and capacitor motors 1/8 to 3/4-hp.

Rotor for shaded-pole fan motors 1/125 to 1/30-hp.

Hundreds of Thousands of Wagner Motors with Cast Aluminum Rotors have been built during the past 25 years and are giving perfect satisfaction.

★

- Wagner squirrel-cage rotors are cast under heavy pressure. The aluminum completely fills the rotor slots and tightly clamps the punchings.
- The rotor bars and endrings make complete and intimate contact with the core-iron, facilitating heat-transfer and absolutely eliminating squirrel-cage vibration.
- The squirrel-cages in all Wagner general-purpose motors are practically pure aluminum of high conductivity and ductility. They successfully withstand the most severe service because they are not affected by repeated heating and cooling and they cannot vibrate.
- A special patented construction is used in the medium and larger sizes to reduce the load losses and increase the motor efficiency.

The mechanical and electrical characteristics, inherent in cast aluminum rotors, have contributed in a large measure to the reputation for quality and dependability established by Wagner motors for the past 50 years.

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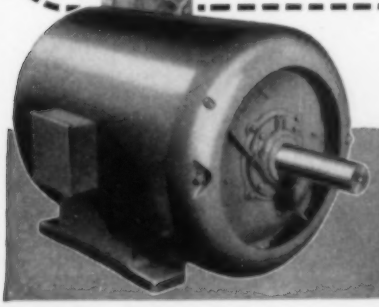
M45-4



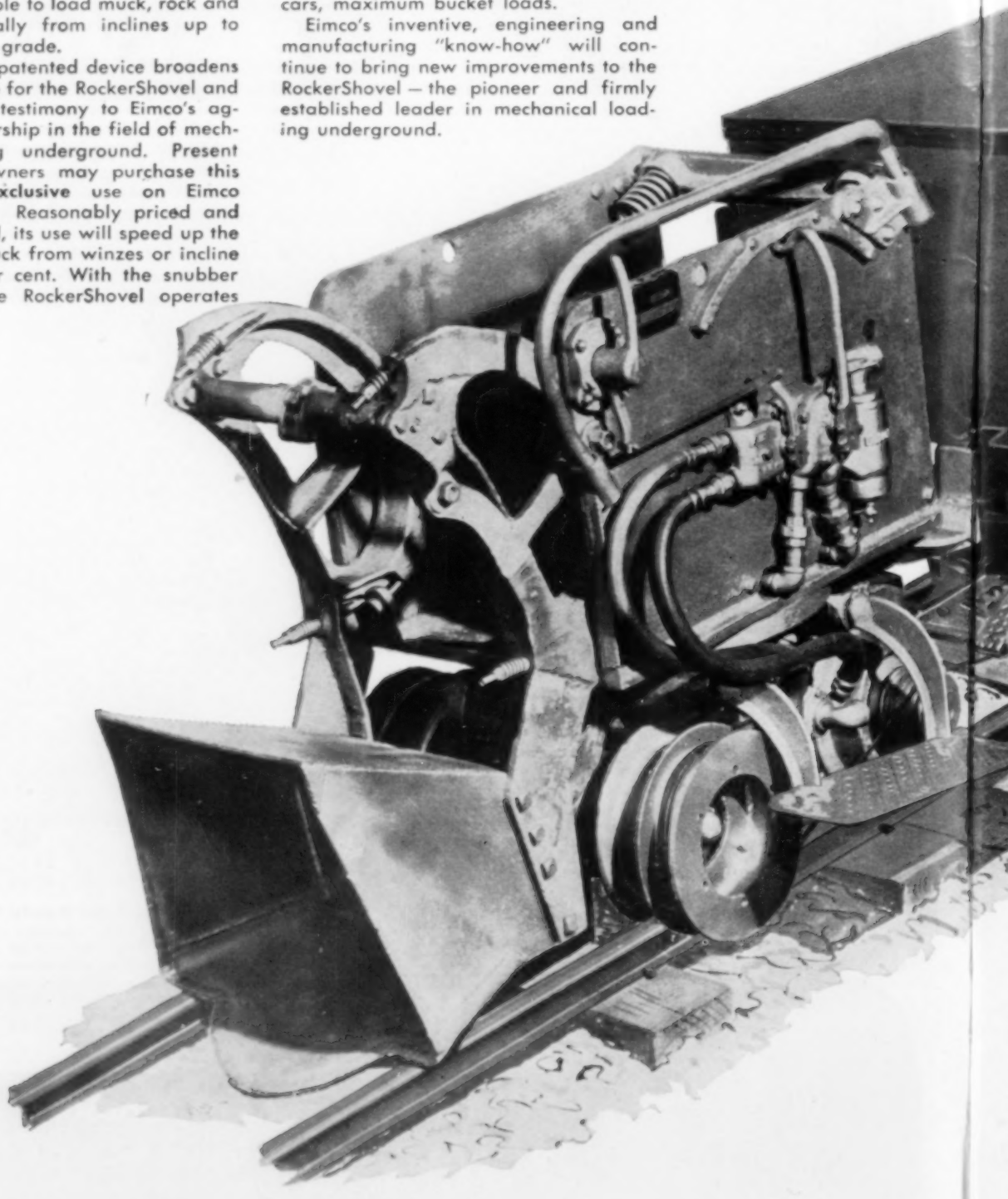
Wagner Electric Corporation
ESTABLISHED 1891
6418 Plymouth Avenue, St. Louis 14, Mo., U. S. A.
ELECTRICAL AND AUTOMOTIVE PRODUCTS

NOW! RockerShovels

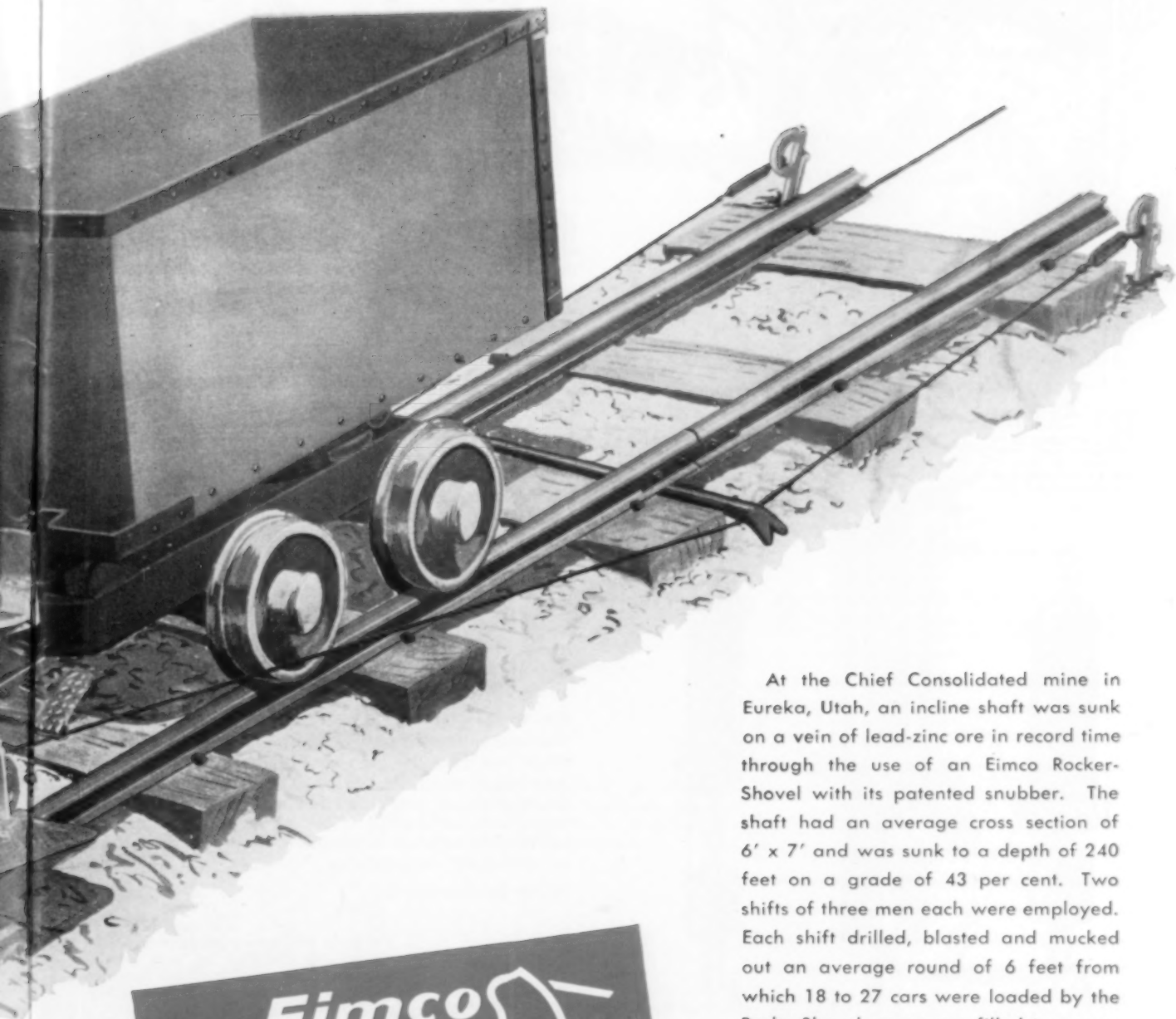
A new Eimco **patented** snubber, which may be attached to any RockerShovel, makes it possible to load muck, rock and ore mechanically from inclines up to 45 per cent in grade.

This simple patented device broadens the field of use for the RockerShovel and bears further testimony to Eimco's aggressive leadership in the field of mechanical loading underground. Present and future owners may purchase this device for **exclusive** use on Eimco RockerShovels. Reasonably priced and easily attached, its use will speed up the removal of muck from winzes or incline shafts 300 per cent. With the snubber attachment the RockerShovel operates as if it were on level track—full tractive power, no track jumping, no special cars, maximum bucket loads.

Eimco's inventive, engineering and manufacturing "know-how" will continue to bring new improvements to the RockerShovel — the pioneer and firmly established leader in mechanical loading underground.



for slope loading



At the Chief Consolidated mine in Eureka, Utah, an incline shaft was sunk on a vein of lead-zinc ore in record time through the use of an Eimco Rocker-Shovel with its patented snubber. The shaft had an average cross section of 6′ x 7′ and was sunk to a depth of 240 feet on a grade of 43 per cent. Two shifts of three men each were employed. Each shift drilled, blasted and mucked out an average round of 6 feet from which 18 to 27 cars were loaded by the RockerShovel; cars were filled to capacity and the average advance per shift was 6 feet as compared to less than 2 feet per shift by hand-mucking.

Eimco RockerShovel

A-85

EIMCO

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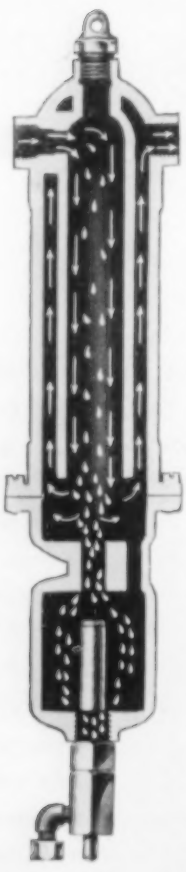

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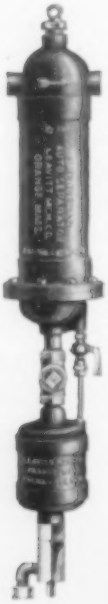

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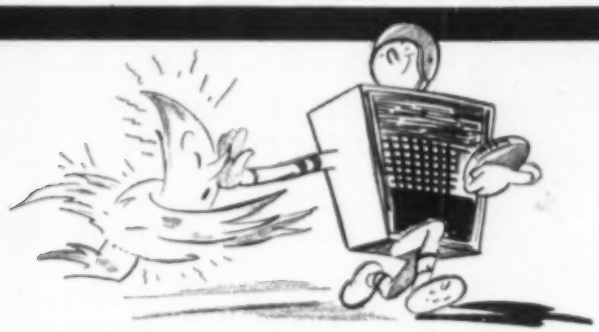

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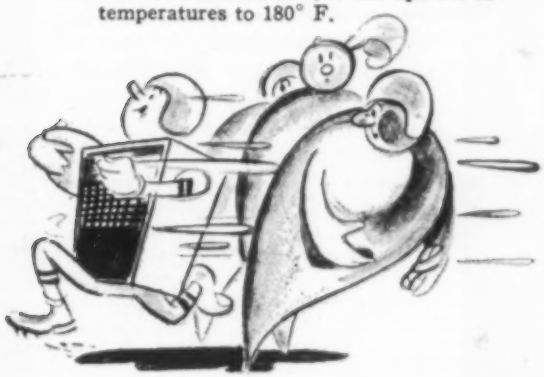

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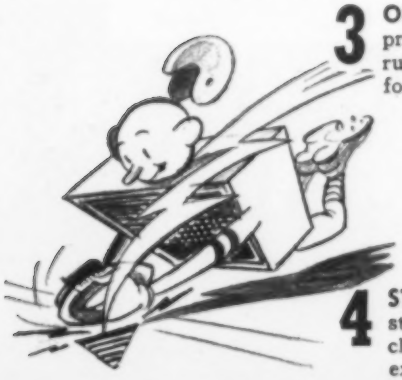

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ON THE COVER

SHIP launchings, always colorful affairs, are brief nowadays. At the Sun shipyard there are generally less than twenty persons in the official party, and the ceremonies take only a few minutes. One man is, however, invariably present. He is Frank McShane, who directs the launching crews. He has "put overboard" every vessel built by Sun since 1920—something more than 330 at the last count. But on December 4 he deserted his usual position on the ways to take a place on the platform. The reason was that his wife had been chosen to christen the ship being launched. Ships are always sponsored by women. Occasionally, a motion-picture personage or other celebrity does the honors, but more often it is the wife or daughter of a Sun employee. In addition to receiving a name at the launching, the vessel is also assigned a number by the U. S. Customs Service. This must be displayed in a designated place. On a tanker it is usually on the forward beam of No. 1 hatch.

The 16,765-ton tanker shown on our cover was christened the *S. S. Murfreesboro* on September 15, 1943, and not long afterward she was involved in a tragic incident at sea. While in a convoy, she collided at night with the freighter *El Coston*. Her cargo of 125,000 barrels of high-octane gasoline was ignited, and a series of explosions ripped her hold asunder and showered flaming oil over a wide surrounding area. Fifty-four crew members of the two ships lost their lives and 29 others managed to swim under the blazing gasoline. They were picked up by escort vessels because their life jackets were fortunately equipped with red lights that they turned on to reveal their locations. The tanker was subsequently repaired and returned to service.

●

IN THIS ISSUE

OUR leading article traces the growth of the Sun Shipbuilding & Dry Dock Company and describes the important work it is doing during the war.

●

THE second article reviews the development of powder for our naval guns and tells how the smokeless powder now used is made.

●

IN OUR third feature article the reader is taken on a tour through the mill of a leading maker of book papers.

●

A TWO-PAGE spread of pictures illustrating varied uses of compressed air, a description of the G-suit that enables fighter-plane pilots to resist black-out, and several other short articles on topics of current interest round out the issue.

Compressed Air Magazine

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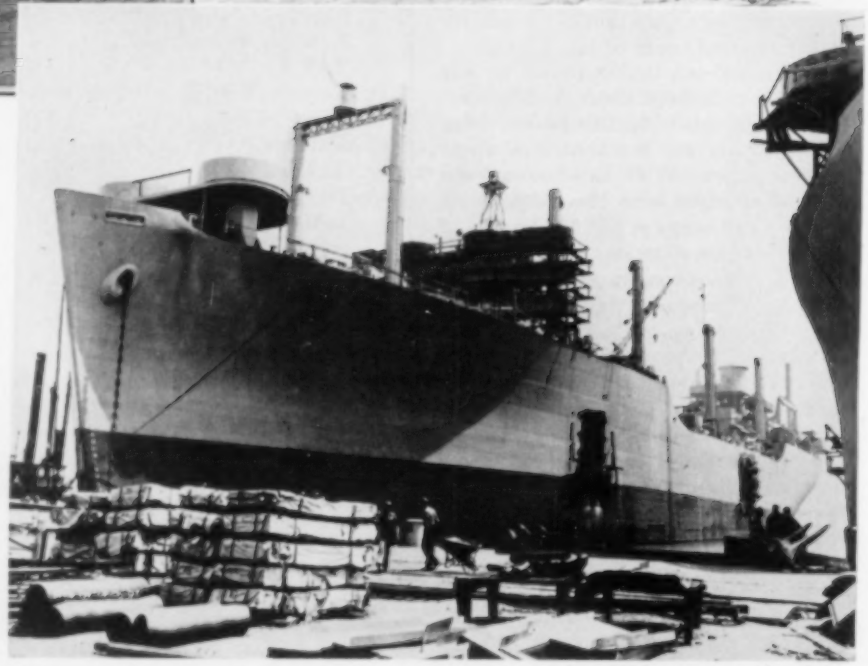
Sun Ships

C. H. Vivian

U. S. Maritime Commission photos



BUILT BY SUN

At the top, the tanker "Gettysburg" is shown immediately after launching. Tugs are towing the vessel to a wet basin, where the remaining work will be done. In addition to about 6,000,000 gallons of gasoline or oil, each T2 tanker bound for a battle area carries special cargo such as airplanes and crated goods on her deck. One thus laden is pictured at the left standing by after joining a convoy at a rendezvous off the east coast. Besides tankers, Sun has built a number of C4 ships such as the one shown just above. The C4 was designed as a troop carrier, but some are used for other purposes. T2 tankers are named for American battles.

IN THE year 1886 the first successful steam-driven tankship for carrying oil in bulk was built in Great Britain. It revolutionized water transportation of petroleum and its fluid products, which had previously been carried in barrels stowed between decks. Ship owners tried unsuccessfully for nearly a quarter-century to devise a satisfactory tanker before the solution was found. In 1863 the hold of the sailing vessel *Ramsey* was equipped with a few tanks, and six years later the entire hold of the *Charles* was filled with 59 such tanks. But the ironwork would not remain tight, and leaks developed. After three years of service the *Charles* came to a disastrous end by burning at sea.

In 1872 the 2748-ton *Vaderland* was constructed in England for the Red Star Line of Philadelphia to carry bulk oil and passengers, but the maritime authorities ruled against such a dual service on the grounds of safety. This ban against passengers on tankers is still in force. Several steamships containing tanks were built in 1879 to transport oil on the Volga River, and they attracted considerable attention; but, generally, it was still considered unsafe to carry bulk oil in other than sailing vessels. In 1886 the sailing ships *Andromeda* and *Crusader* were fitted with cylindrical tanks of improved design intended to overcome leakage, but they were quickly overshadowed by the appearance of the first steam-driven tanker embodying the modern principle of subdividing the entire hull into compartments rather than building in tanks.

This forerunner of today's tankers was the *Gluckauf*, which was constructed at Newcastle, England, for Wilhelm D. Riedemann of Geestemunde, Prussia, who had been operating two sailing vessels for the transport of petroleum in barrels. No German firm would build the ship he had in mind because all believed it presented too great a fire hazard, so Riedemann went to England and succeeded in getting Armstrong, Mitchell & Company to undertake the job. The *Gluckauf* was 300 feet long and had a dead-weight (carrying) capacity of 3000 tons. In addition to subdivided compartments, provisions were made to take care of expansion and contraction of the oil under varying temperatures, and pumping equipment was included for loading and discharging, all of which are essential features of modern tankers. The vessel sailed for the United States on July 13, 1886, to take on cargo, and

FIRST-SHIFT WORKERS LEAVING THE SHIPYARD

immediately aroused a protest from American longshoremen who found that very little labor on their part would be required to load it.

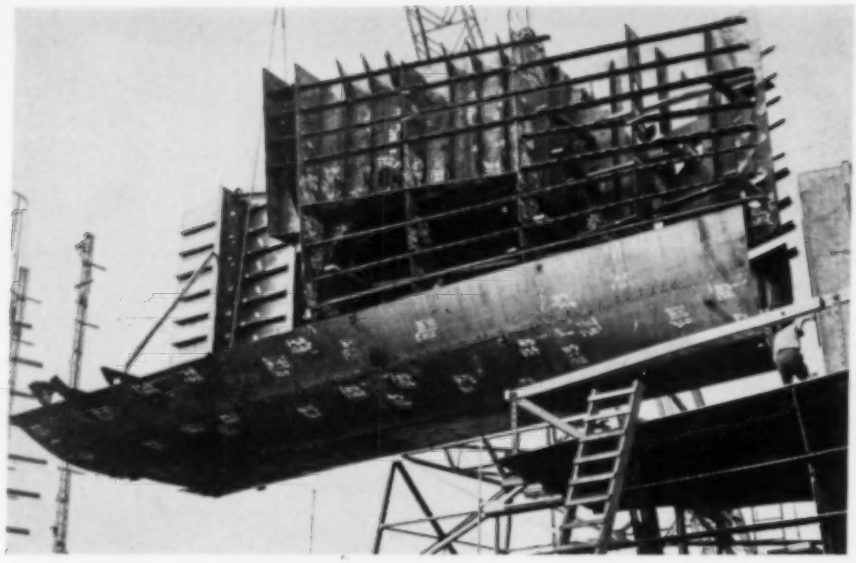
The ship carried 22,000 barrels of oil, the equivalent capacity of three vessels under the then prevailing system of putting it in barrels, and could be loaded in three days instead of the usual month. Members of the Produce Exchange in New York expressed the fear that such ships would transfer the refining of American petroleum to Europe, where costs were less than here. There was talk of petitioning the Congress to bar the use of tankers, and the Standard Oil Company was asked to refuse oil for shipment in them. But the march of progress could not be halted. The *Gluckauf* was such an immediate success that Riedemann ordered four similar vessels, and in a few years tankers were carrying oil on the Seven Seas. They now represent about 10 percent of all merchant shipping.

In the same year the *Gluckauf* was constructed abroad, a 16-year-old lad obtained his first job as a pipe-fitter's helper in Pittsburgh, Pa. This comparatively inconsequential event is grouped here with the first one because the years that followed served to bring about a definite relationship between them. For when the pipe-fitter's helper grew up, he became the chief executive and guiding spirit of an American concern that has had a leading part in the development of the modern tanker. He is John G. Pew, Sr., who has been president of the Sun Shipbuilding & Dry Dock Company of Chester, Pa., since 1918.

Numerous war-born shipyards now dot our three coast lines, but in the peacetime interval between the two world conflicts we were not a leading shipbuilding nation. There were few yards that could be called permanent, and those among them that were actually constructing merchant vessels could be counted on the fingers of one hand. The Sun yard was one of the few. It built various types of ships, but was known in maritime circles as a specialist in tankers. Proof of this is found in the fact that the standard wartime tankships now being constructed not only by Sun but by other yards are of Sun design. They are the T2-SE-A1 vessels that constitute an important part of the emergency shipbuilding program of the U. S. Maritime Commission.

American motorists need not be reminded that enormous quantities of gasoline and other petroleum products are being transported to the fighting fronts, for that is the basic reason for gasoline rationing at home. We are not told just how much gasoline and other fuel oils are leaving our shores, but the Office of War Information states that one armored division on the march uses 650 tons of gasoline daily. The thousands of Allied airplanes that are in the skies almost the clock round consume additional huge amounts of fuel, as do the great fleets of naval and merchant vessels that are oil-fired. A large percentage of these supplies is being carried in American tankers.

The pipe-fitter's job in which John G. Pew began his industrial career was with the Peoples Natural Gas Company, and he remained with that organization for 32 years. After he had become head of a pipe-fitting gang, he began educating himself by taking night courses in drafting and various engineering subjects, and he continued this formal study intermittently for fourteen years. He advanced to superintendent of the Forbes Street shop, and when the Standard Oil Company of New Jersey bought the gas company he became its vice-president and general manager. In 1908 he was named president and directed operations until 1918, when he resigned to become an executive of the Sun Oil Company. The latter concern had organized the Sun Shipbuilding Company in 1916, and Mr. Pew assumed charge of it in April, 1918.



LARGE ASSEMBLY

To lessen the work on the shipways, assemblies are built up as far as possible beforehand. Shop loads are limited to about 15 tons by crane capacities, but some sections are further fabricated on the ground adjacent to the ways before being hoisted into place. Shown above is a 100-ton forward assembly being lifted by two traveling gantry cranes. It is made up of the fuel-oil and forepeak sections.

The Sun yard is located on the Delaware River not far from the site of the nation's first steel shipbuilding establishment. When Sun began operations, most vessels were driven by reciprocating steam engines, so the concern acquired the Robert Wetherill Engine Works that it might have its own plant for the building of propulsion machinery. Wetherill Corliss engines and Scotch boilers were installed in all Sun ships constructed up to 1923, and many of those power plants also went to other shipyards. Meanwhile there was an increasing trend away from reciprocating engines; and in 1923 the company obtained the exclusive American license to build the English Doxford marine diesel engine, which it has since turned out as the Sun-Doxford unit. The first of these was manufactured in the Wetherill shops the same year for the tankship *Miller County*. Production of Sun-Doxford engines continued until the current wartime shipbuilding program was well advanced; and they were made for other yards than Sun, with the result that they are in more American-built motorships than any other diesel unit.

In 1921, with the construction of the first of its two dry docks, the company organized a ship-repair department and changed its name to the present one of Sun Shipbuilding & Dry Dock Company. But even before this time the yard had begun to use welding in place of conventional riveting in the fabrication of some parts of small craft, and considerable welding was also done in making repairs. Meanwhile the Wetherill shops started making pressure vessels, plate work, and special equipment for the oil-refining industry, and welding was increasingly employed in this work. All these efforts dovetailed—led to the gradual evolution of the all-welded ship which Sun claims as one of its important contributions to the shipbuilding art.

As early as 1919 several towboats were fabricated by welding, and then some coastwise tankers of 250-foot length and 30-foot beam. The first large seagoing vessel of all-welded construction was the *J. W. Van Dyke*, an 18,000-ton tanker built for the Atlantic Refining Company in 1937. Eight more large tankers were then constructed for the same concern, and several others were built for the Sun Oil Company. By the time Sun entered upon its wartime program, all-welded construction had become accepted practice with it.

Ships of the size now being built formerly required the driving of approximately 900,000 rivets, which have been replaced by some 60 miles of welds. The principal advantage of welding is a saving in weight of steel of around 15 percent chiefly because there is no overlapping of plates. This obviously lowers the cost of material and also permits a vessel to carry additional cargo or to house a heavier, more powerful propulsion plant, or both. Sun executives say, too, that the all-welded ship can be fabricated quicker and at less cost than the riveted one, and that it is considerably easier to keep in good repair.

Two types of ships are being built by Sun for the war: tankers and C4 cargo carriers, with the former greatly predominating. From the time of the Pearl Harbor attack to January 1, 1945, the yard has produced 151 tankers and twenty other vessels for the U. S. Maritime Commission and 31 tankers for various oil companies. The T2-SE-A1 type tanker, which has made up the greater percentage of this construction, has an over-all length of 523½ feet, a beam of 68 feet, and a molded draft of almost 30 feet when fully laden. Its net tonnage is 6107, and its peacetime dead-weight tonnage is 16,745. This is equivalent to 141,160 barrels of gasoline. It is a single-screw vessel equipped with turbine-electric propulsion machinery developing 7500 normal shaft horsepower, and has a rated speed of 15 knots. Steam is generated in oil-fired boilers, and there is fuel capacity sufficient to give the tanker a cruising radius of 12,600 miles.

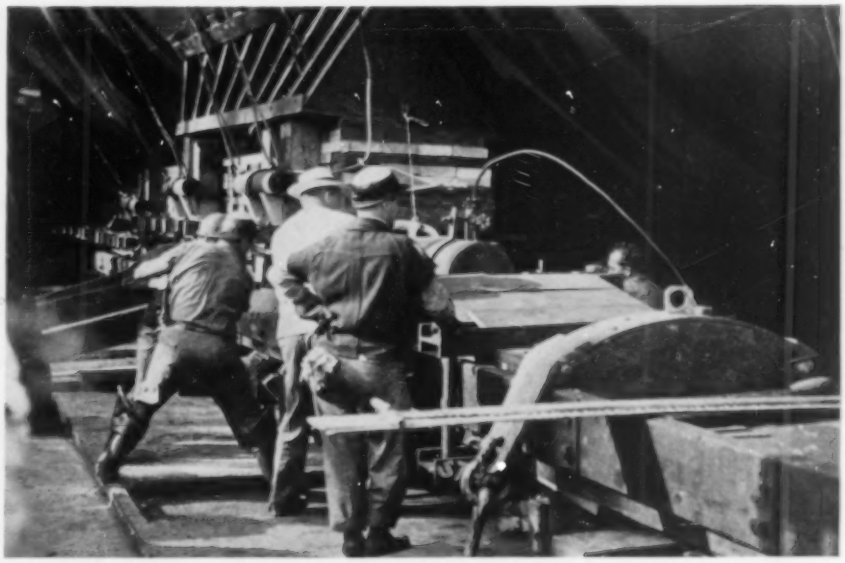
Of the twenty other Maritime Commission ships so far built eight were freighters and the rest were fitted out for special services—six as troop transports and six as Navy hospital ships. This type of vessel has an over-all length of 522 feet 10½ inches, a beam of 71½ feet, and a draft, when loaded, of 32 feet; its dead-weight tonnage is 14,600; and it is driven through gears by a turbine developing 9000 shp. Its cruising radius is 14,560 miles.

The total of 202 ships put in the water since December 7, 1941, is about equal in number to the entire output of the yard in the 25 previous years of its existence and greatly exceeds all prior production on a tonnage basis. This acceleration is the result of a vast government-financed expansion both in physical facilities and number of employees, coupled with a greater output per worker. On March 1, 1941, the yard had eight ways, two dry docks, and 7700 men, most of whom were experienced. Eighteen months later there were 28 ways, with the necessary appurtenant shops and outfitting basins and 30,000 employees. Subsequently the payroll rose to 36,000, from which it has since dropped to around 27,000. It would still be at the 36,000 peak, or even higher, if the workers could be obtained. More than 16,000 of the yard personnel have entered the armed services, and there have been other thousands of detachments for various reasons.

This expansion came in three steps, the first two of which overlapped. The initial enlargement, which was started in February, 1941, consisted of four ways adjoining the original ones on the south. Two months later ground was broken for eight additional ways just north of the existing ones. In March, 1942, construction was begun on eight more to extend the establishment still farther northward. Although the 28 ways are continuous, the four groups are set up as individual shipbuilding units and are designated, from south to north, as the South Yard, Central Yard, North Yard, and No. 4 Yard. With the exception of

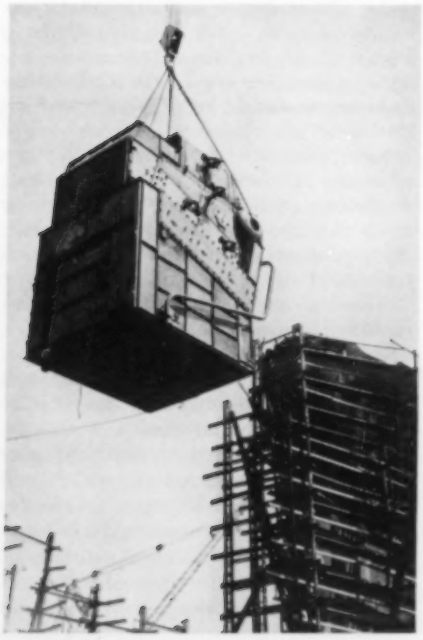
some of the leaders and foremen, all workers in No. 4 Yard are Negroes. The four units stretch along the west bank of the Delaware River for 2 miles and represent what is claimed to be the largest single shipyard in the nation.

As the yard grew and thousands more workers had to be recruited, it became impossible to get experienced men. Many of those hired had never seen the inside of a ship. It was consequently necessary to train them and to do it quickly. In normal times the company had maintained apprentice courses, but these were not geared to the current needs. Special classes were therefore organized in several branches of the work, and advantage was also taken of the training-plan facilities provided by the Government. Some 1800 men enrolled for courses in drawing, mathematics, marine electrical engineering, mechanics, strength of materials, power-plant operation, naval architecture, and practical ship design. Five hundred leaders and foremen entered classes in foremanship at Swarthmore College. A like number of leaders, foremen, and first-class mechanics took instruction to qualify themselves to teach others. Nearly 7000 men on the vocational level registered for courses in ship fitting, erecting, marine electrical installation, blueprint reading, sheet-metal layout, fabrication, machine-shop practice, and other shipyard crafts. Aptitude tests were taken by 3000 Negroes as an aid in determining what they were suited for. Similar educational facilities have since been maintained to qualify new workers as they are hired, and thousands have been quickly and effectively equipped for their jobs. To mention only one of them—the number of welders trained to date totals 7500.



STARBOARD CUT-OFF LAUNCHING CREW

A tense prelaunching moment. Supporting blocks have been removed from underneath the length of the hull, and the 5500-ton ship is held entirely by two strips of heavy timber, one on each of the two ways. These tie the sliding ways to the fixed ways and are cut through in unison to release the vessel. A crew similar to the one shown works on the port-side way. Four men operate each saw, and a spare one, visible in the foreground, is always at hand in case it is needed. The top of a hydraulic cylinder and its supply line may also be seen at the right of the near man. This is available to give the supporting cradle a starting push if required, but it is seldom called into use. The ways slope toward the river, ¾ inch to the running foot, and a tanker is normally in the water 46 seconds after it has been cut free.



A BOILER GOES INTO A HULL

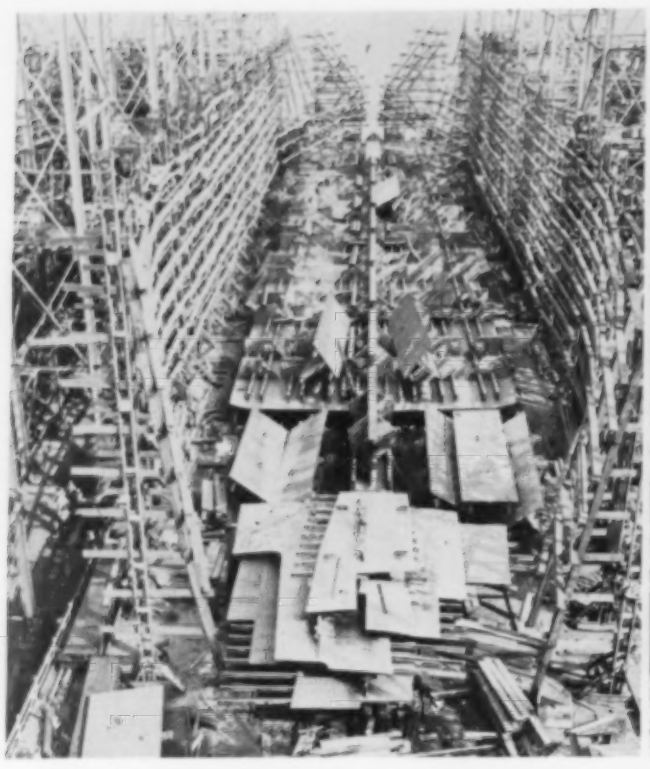
This Babcock & Wilcox marine boiler is capable of converting 32,000 pounds of water into steam every hour. Two such units are installed in each tanker.

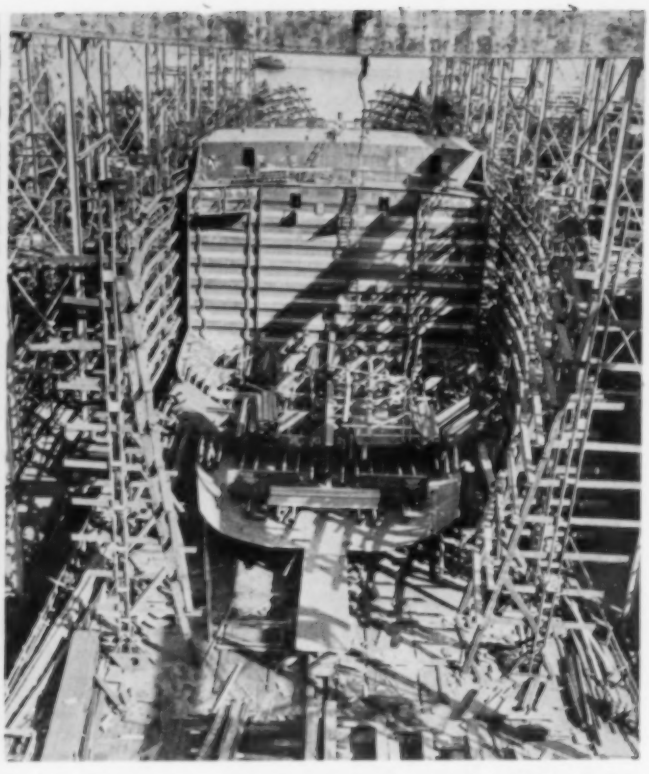
As a result of improved techniques, intelligent planning, thorough organization, and capable direction of the multifarious tasks involved, together with adequate training of inexperienced workers, Sun has compiled a praiseworthy record of ship construction in this war. How favorably it compares with the yard's performance in World War I may be learned from the statement made by President Pew on March 23, 1943, when Rear Admiral Emory S. Land, chairman of the U. S. Maritime Commission, presented the Maritime "M" to the organization: "In the first World War," Mr. Pew said, "10,000 workers produced one 10,000-ton, 10-knot ship per month. Today, 30,000 workers are producing six 17,000-ton, 16-knot ships—five times the carrying capacity per unit of worker."

The output of six ships per month, to which Mr. Pew referred nearly two years ago, has been more than maintained since then, despite a reduction in workers. The 1944 production was 81 vessels, an average closer to seven than six a month. In addition, 35 car floats were constructed, and a continually increasing volume of repair work was handled because of the growing number of Sun-built ships engaged in war service. There have been months when eight completed vessels were delivered; and back in 1942 there was a triple launching on Memorial Day, the first one in the yard's history. Sun was constructing ships for the Maritime Commission before we formally entered the war, and in July, 1941, the tanker *W. C. Yeager* was launched 3 months and 18 days after keel-laying and delivered in an elapsed time of 4 months and 29 days. Both performances set new records for a tankship more than 450 feet long, but at present they are eclipsed regularly in routine schedules. The average time now required to build and equip a tanker is 3 months and 10 days.

In considering these figures, the vessels to which they pertain should not be confused with the Liberty ships of the Maritime Commission's emergency building program that was adopted for the war period. The Liberty is a 10-knot vessel of 10,800 tons dead weight with few refinements and was designed specifically for mass production, with hundreds of producers of parts funneling their outputs to the yards for fabrication. The ships Sun is constructing are of the same high standard as those projected in the Maritime Commission's long-range building program inaugurated in 1937 "to revive America's moribund merchant marine."

The schedule drawn up then called for 50 of the C-type a year, and also included twelve fast tankers. These were of the Neosho type—18,000-ton vessels





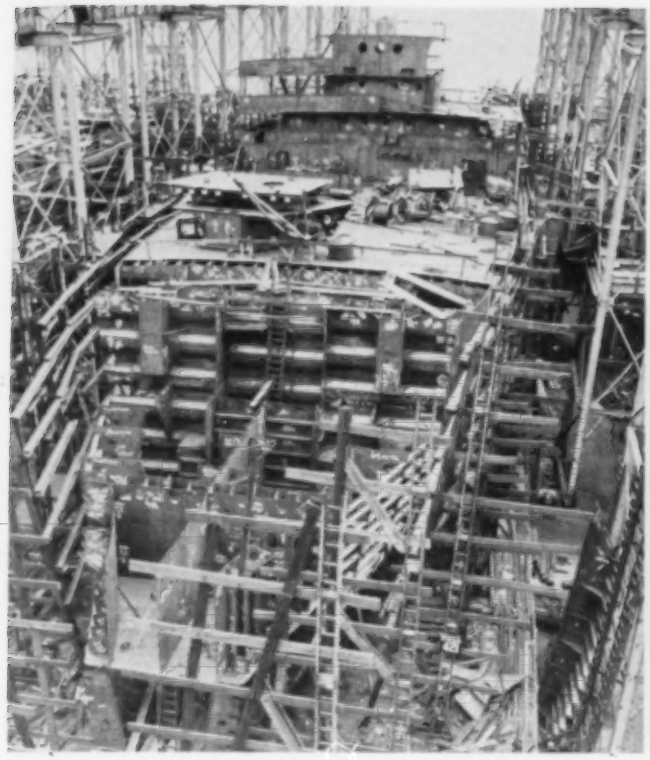
propelled by steam turbines developing 13,500 normal shaft horsepower and driving twin screws to provide speeds much higher than those of conventional tankships in the oil industry. Sun submitted the low bid for all twelve, but because it did not then have the facilities to construct them all at once, the contract was divided among four yards. Sun built three, the *Cimarron*, *Seakay*, and *Esso New Orleans*, which were launched in the early part of 1939. They and their nine sister ships were taken over by the U. S. Navy, which altered their superstructures, added armament, and placed them in commission to service battlecraft. One of them, the *Neosho*, was berthed near the ill-fated *U. S. S. Oklahoma* off Ford's Island, Pearl Harbor, when the sneak Jap attack was made, but steamed away and escaped damage. She eventually was sunk by a torpedo from one of our own naval craft after she had sustained mortal wounds from Jap bombers in the Battle of the Coral Sea. Her exploits were recorded in a *Saturday Evening Post* article in the February 6, 1943, issue under the title *Fat Girl*, a sobriquet given the vessel because of her bulbous prow. In recent weeks Sun was awarded a contract for five additional tankers of this class.

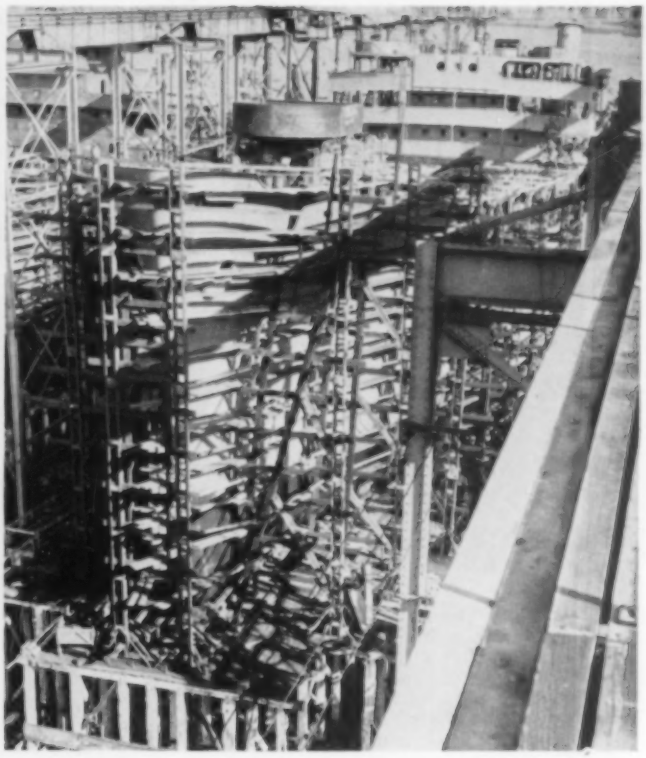
When we became embroiled in the war, the Maritime Commission standardized chiefly on T2 tankers which, as already mentioned, are of Sun design. Although somewhat smaller and 3 knots slower than the Neosho type, they are just as well built in every respect, and no sacrifice in quality has been made to speed up output. While Sun has many suppliers of parts and equipment for these ships, the latter cannot be placed in the same mass-production category as Liberty ships. They are still constructed with the same care and attention to detail as they were before the emergency arose, and there has been no wholesale "farming out" of parts to be sent to the yard and assembled there.

In addition to creating the all-welded ship, Sun has shown in other ways its willingness to embrace and to help develop new ideas. It aided in financing the Seatrain scheme of carrying loaded boxcars from port to port, designed the hulls for the vessels, and has built four of them for the operating company, Seatrain Lines, Inc. These are 478-foot, 15½-knot ships with four lines of standard-gauge railway tracks on four levels—approximately a mile in all. Each Seatrain transports 100 cars and is equipped with special machinery for loading and unloading them. The fleet was in successful service until it was requisitioned by the War Shipping Administration in April, 1943. Sun is also one of the backers of the scheme for establishing Seadromes on the high seas for use by transoceanic air lines. These floating landing fields, which were invented by Edward R. Armstrong, were the subject of an article in our March, 1944, issue. Plans for the first of these structures are fully developed, and construction is scheduled to start as soon as the necessary steel and other materials can be obtained.

It is not within the scope of this article to describe the shipbuilding procedure in detail, but it will be outlined briefly. Sun tankers are constructed in conformity with the longitudinal system of framing originally advanced by J. W. Isherwood. Each vessel is essentially a huge box girder, the shell being inwardly supported and stiffened by series of longitudinal and transverse members. As is the case with all ships, a tanker first takes form in the minds of naval architects. They decide upon the basic elements such as size, weight, capacity, power, speed, and general arrangements. This information is given to the drafting department which, at Sun, is divided into the hull, engine, and electrical units. Among them they prepare detail plans of every part of the vessel. The hull draftsmen first make a profile drawing of the ship showing exactly where everything goes, and then break this down into deck plans, cargo-tank plans, etc.

The hull drawing room is organized in three groups: scientific, structural, and fittings. The scientific section prepares drawings indicating how the hull is to be shaped and makes the calculations that insure bulkheads, stiffeners, etc., of the required strength to give the tanker the internal support it will need. The structural group makes the plans for the decks, framings, large bulkheads, stern, and the large sections of the 52-ton bow. It then constructs a scale model of the vessel from wood and indicates on it the exact size and position of each skin plate. The fittings section plans the anchors, chains, lifeboats, etc. This group also figures out the refrigeration capacity and size of galley that will be required. From these various





A TANKER TAKES FORM

This series of progress photographs of Hull 421 gives a good idea of how a tanker is put together and of the great number of individual parts that enter into its construction. Each part is marked beforehand with its exact position in the ship. The placing of propulsion machinery begins at about the stage shown in the second picture. The series was taken one month apart.

drawings is compiled a list of the materials that will be needed, and this is turned over to the order and the purchasing departments so that inquiries can be made and everything bought with delivery dates arranged to meet the building schedule. Copies of the drawings go to the loft and the fabrications departments and to the shipways.

Since the days of wooden vessels, the mold loft has had an indispensable place in shipbuilding. It is there, for one thing, that the vessel is "faired," which means taking suitable steps to give it graceful lines. Under modern methods of fabricating steel ships the mold loft has gained rather than lost in importance. The drawings received by it show the shape of the vessel at successive transverse sections ranging from 20 to 40 feet apart. These are checked or faired on the loft floor by the "line gang," after which two body plans are prepared. Each shows respective cross sections or slices through the hull from stem to stern at intervals of from 24 to 30 inches. The sections forward of amidships are on the right side of the centerline and those aft are on the left side. Since both halves of each section are alike, only one need be indicated. The two body plans are penciled on the loft floor and are referred to continually thereafter to keep the shape of the ship true. They become the basis of all construction work in the loft, in the fabricating shops, and on the shipway.

From the plans the loft line gang makes a complete set of dimensions for the various cross sections, giving the half-breadth and height in each case. The scientific department compiles these in a form suitable for use and issues them as "final offsets from the mold loft." Then follows the loft's all-important task of fashioning templets or patterns that serve as guides in shaping the steel parts for shop and shipway construction. To facilitate this work, the loft personnel is divided into "gangs" of from two to twelve men each, according to their assignments, and each has a leader. The latter is given a blueprint of, let us say, a bulkhead.

From the body plan the leader obtains dimensions for making a temporary shape of the given member. These he transfers to his bench, where he makes a "layout" by building into the shape the templets of the plates, angles, braces, etc., shown on his blueprint. That they may be light and easy to handle or store, the patterns are of wood. Each is of the exact shape and size as the counterpart to be made of steel and is marked with the number of the hull in which the finished part is to go and the position it is to occupy. This is done by referring to certain lines such as center, base, frame, buttock, and water lines.

The centerline cuts the hull in half longitudinally; the base line is a horizontal line at the level of the lowest shell plate; frame lines are perpendicular to the centerline and give positions on the ship from stem to stern; buttock lines, which are parallel to the centerline, show points outboard from the centerline; and water lines, which are parallel to the base line, indicate positions between the base line and the top of the hull. This information is later transferred from the templets to the pieces made from them. Meanwhile the loft has received from the drafting room bills of material (known as BMs) showing in what forms and sizes the steel will arrive at the yard. These BMs enable the loftsmen to keep the patterns within the limits of the material ordered.

When all-riveted ships were built, each rivet passed through at least two, and sometimes three, thicknesses of steel; and in making the templets for a single vessel the loftsmen had to locate some two million rivet holes with such accuracy that matching ones in the overlapping sections would come together. In the all-welded ship, this work is eliminated, but the loftsmen must know just how welding will affect expansion and contraction of varying thicknesses and shapes of steel in the assemblies and make due allowance therefor in the templets.

Since the wartime tankers are all identical in hull size, it is obvious that the mold loft does not have to go through the entire process described in the case of each one. In most instances, patterns can be used over and over, but damage and breakage call for continual replacements. These are made by the loftsmen

WELDING

The welding department is the largest single division in the yard. Welding is required at all stages of construction and on almost every part entering into a ship. Nearly every type of welding is used, with the Unionmelt and electric-arc processes predominating. The average thickness of steel plate employed is within the range from 5/8 to 7/8 inch, with an upward limit of 1¼ inches. Some 60 miles of welds are made every five days, and their soundness is checked by examining and testing 75 samples from each vessel. Various types of pneumatic tools are used extensively in the welding procedure.

in the same way as the original ones were.

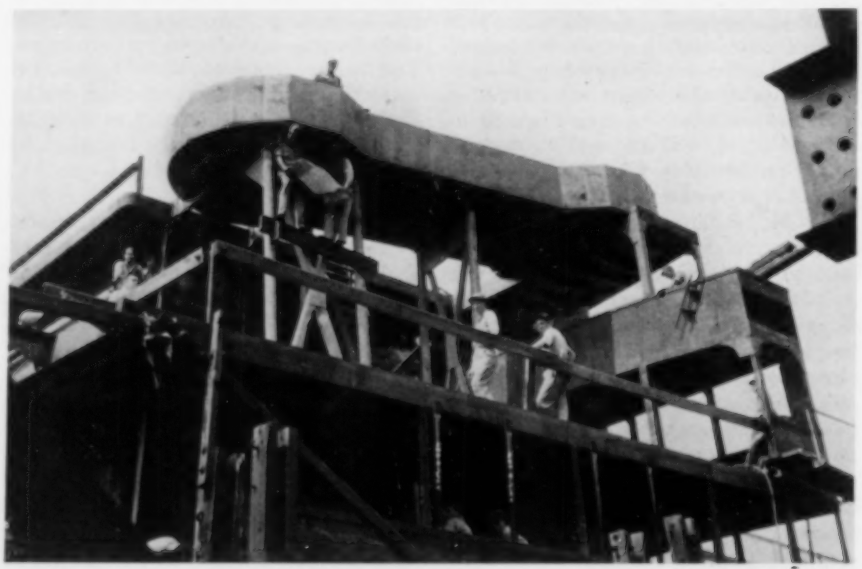
Fabrication of the steel for hull construction is done in shops just shoreward of the shipways. As each section is built, in turn, the necessary templets are obtained from storage and steel is requisitioned from stock, as covered by the bills of materials. Let us assume that a bulkhead plate is to be fabricated. The plate is first put on skids in the laying-out shop where the proper templet is placed on it and positioned correctly by reference to a series of lines and measurements put there by the loftsmen. The outline of the templet is then marked on the plate, and information such as size, shape, etc., is copied on it from the templet to serve as a guide in the various shops. The plate is next carried by an overhead crane to an automatic burner where an oxyacetylene flame cuts it to the prescribed pattern and also bevels the edges, as may be required, to facilitate subsequent welding. Some plates are cut by large gate shears instead of being burned. In either case, the plates go to an automatic welder where they are set together by means of "match marks" copied from the templet and are welded on one side. The assembled unit is now moved to an area where extra brackets, etc., are fitted and welded on by hand. That done, it is turned over, the reverse sides of the seams previously welded are chipped out, and final welding is done from that side. The lofting gang then takes charge of the assembly and lays it out with the aid of templets and data to the exact size and shape so that it will fit into its particular place in the ship, burners removing the metal outside these markings.

The shops are outfitted to bend and otherwise to form plate or structural shapes of different kinds. Plate is usually worked cold, while structural shapes ordinarily require heating. Some riveting is done on such parts as deck-plate assemblies. Mechanics of many classes make up the personnel of the shops, among them being layer-outs, punchers, shearmen, planers, cold pressmen, burners, chippers, fitters, welders, roll men, countersinkers, etc. Each does his alloted work on a part as it advances, somewhat in the manner of a factory assembly line. The aim is always to keep the material moving towards the door and the shipway, with little or no backtracking. Every effort is also made to do as much of the assembling as possible in the shops, to lessen such work on the shipways where it is harder to do. The size of the units that can be assembled in the shops is limited primarily by the lifting capacities of the cranes. Pieces weighing up to 15 tons are regularly produced, while larger ones are sometimes fabricated by doing additional work on them adjacent to the shipways, where large gantry cranes are available.

When naval architects lay out a vessel, they first provide for cargo space and crew's quarters, leaving just enough room for the propulsion machinery and allied equipment. Consequently, as anyone who has looked inside a ship knows, the engine room is somewhat reminded of the interior of a can of sardines. The amazing thing to the casual observer is how so much machinery, apparatus, and piping can be put into such a limited space. Seeing to it that it all gets in, properly positioned and connected to perform its all-important work efficiently, is the task of the yard's engineering department. While the hull-drafting and mold-loft groups are getting the ship put together right structurally, the engineering department is planning the power plant.

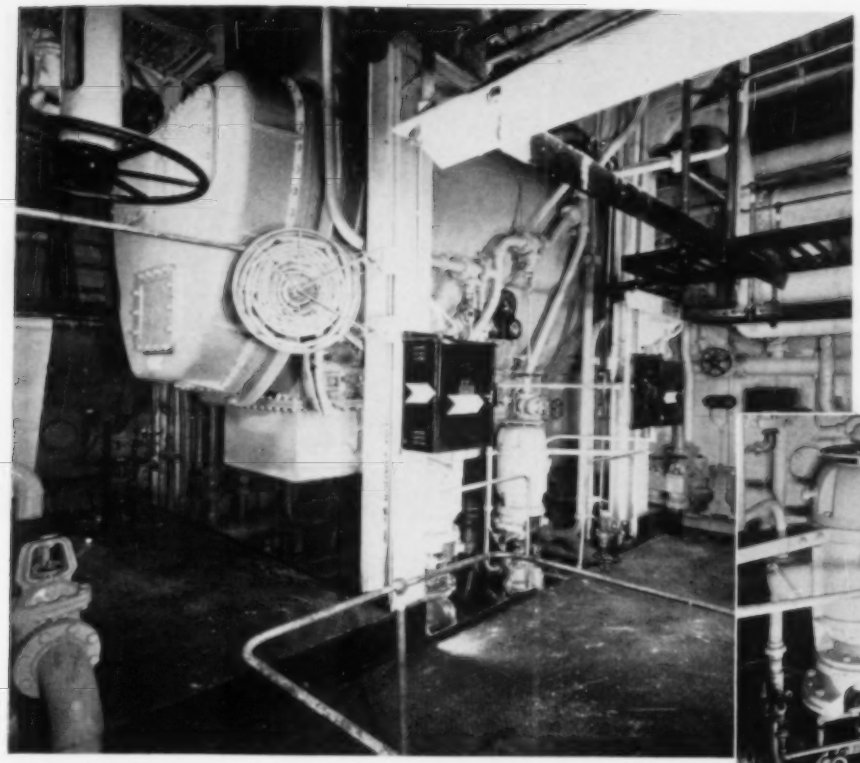
The propeller shaft of each T2 tanker is turned by an electric motor that receives its current from a turbine-driven generator. There are also two smaller turbine-generators to supply current for lighting the ship and power to operate various motors. This is a flexible arrangement and makes it unnecessary to run the main generator when the ship is in port. Two oil-fired boilers provide steam for the turbines at 450 pounds pressure and 750°F. total temperature. To condense the steam leaving the turbines there are a main condenser and an auxiliary unit and each has its complement of pumps to circulate cooling water through the tubes and to handle the condensate, which is recharged to the boilers by feed pumps. Then there are cargo pumps and others for handling fuel oil and lubricating oil, as well as water pumps for fire, sanitary, and butterworth (cargo-tank purging) services. Manufacturers of all these items cooperate with the yard engineers by designing them as compactly as possible.

The engineering department is also responsible for such equipment as the steering gear and both deck and anchor winches. Another of its jobs is that of laying out the different piping systems



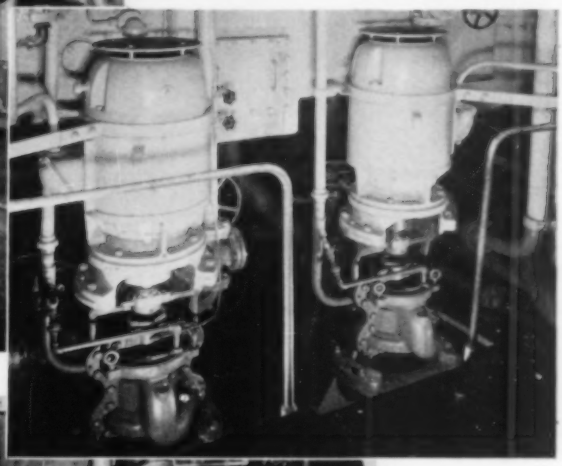
SHIP FITTERS

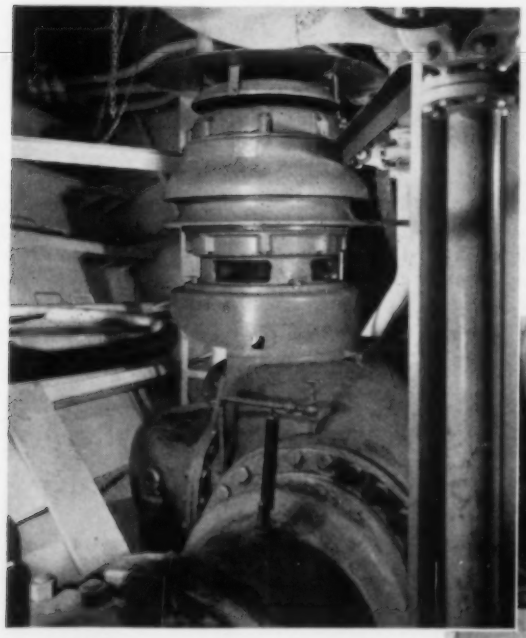
Ship fitters are responsible for the correct placing of all steelwork and follow assemblies through the shops and on the shipways. The group shown here is setting an antiaircraft-gun foundation on the deck of a tanker.

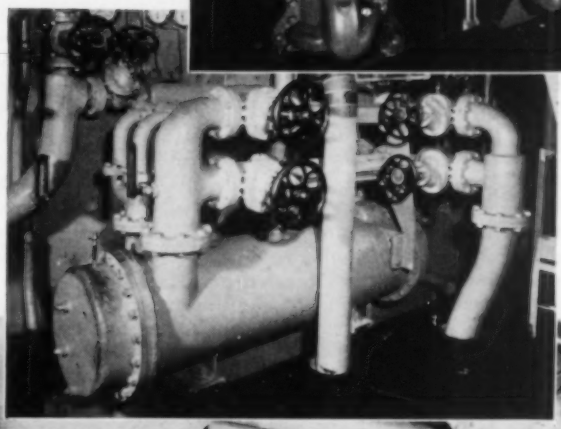


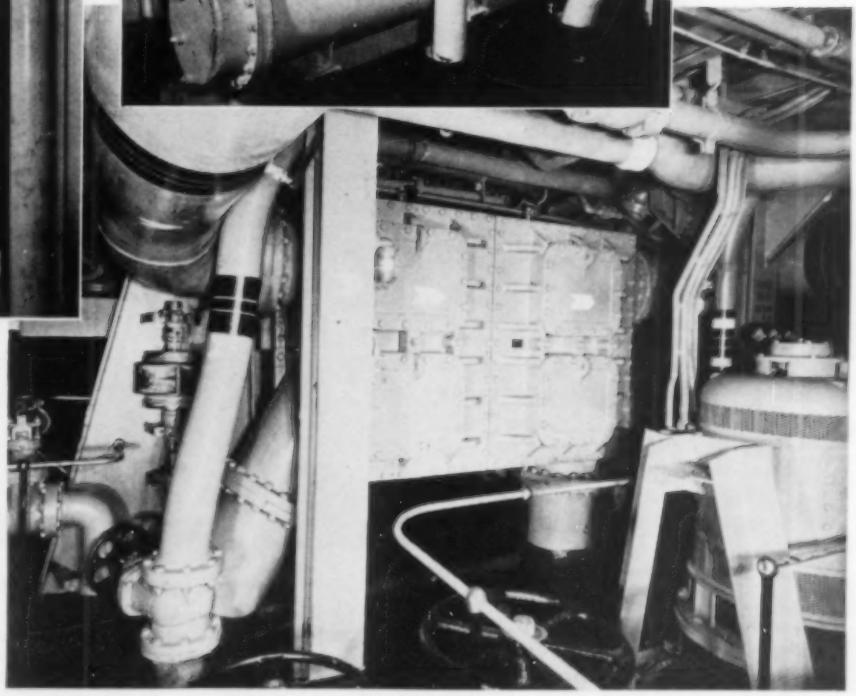
TANKER MAIN CONDENSER

The Ingersoll-Rand surface condenser at the left serves the main propulsion turbine, which is immediately above it on the next deck. It is a 2-pass unit, with 8280 square feet of surface and condenses 65,900 pounds of steam per hour with a vacuum of 1½ inches absolute and 75°F. water. When under full load, 12,800 gpm. is circulated through it by the vertical I-R pump shown below it. The condensate is handled by two I-R pumps (directly below), each of which has a capacity of 180 gpm. against a head of 220 feet. Air and other noncondensibles are removed from the steam by the I-R 2-stage twin-element steam jet shown at the right-center.



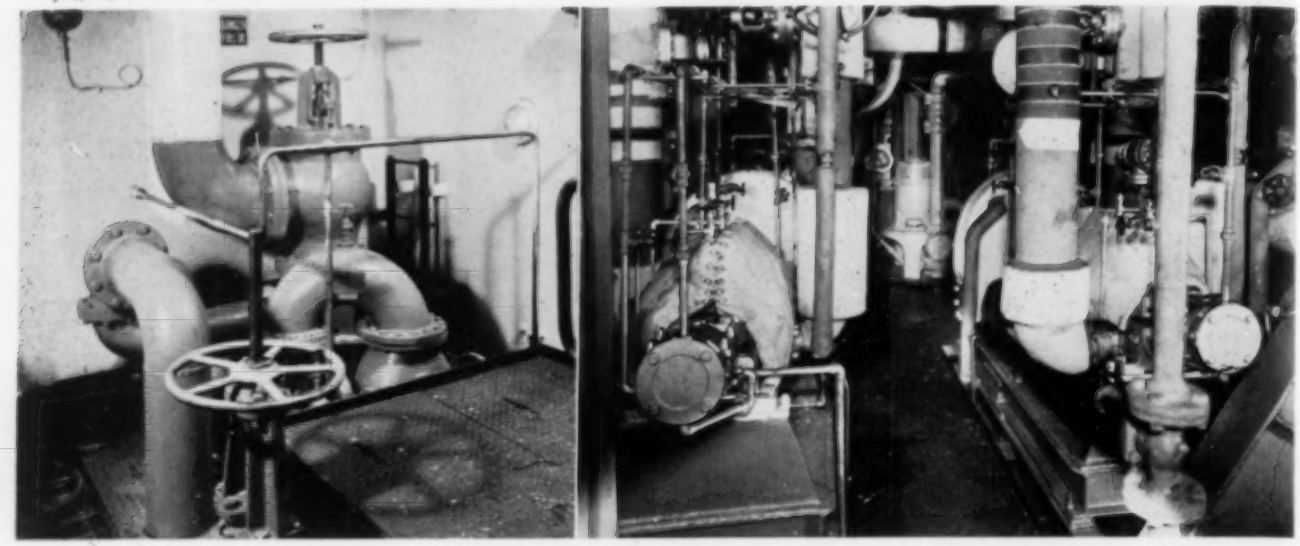






CARGO-SHIP CONDENSER

The picture at the right shows the inlet end of an Ingersoll-Rand rectangular condenser that serves the main turbine on a C4 ship. The condenser is split vertically in the center so that one side can be shut down for cleaning while the other side remains in service. It has 9300 square feet of surface and will condense 67,000 pounds of steam an hour.



BOILER-FEED AND CARGO PUMPS

The most dependable machinery obtainable is selected for wartime tankers. Pumps of various types and for different services are important parts of the equipment. Shown at the right are two Ingersoll-Rand centrifugal boiler-feed pumps such as have been supplied for all tankers and cargo ships built or being built by Sun on wartime contracts. Each unit delivers 200 gpm. against 575 pounds pressure and is driven by a 115-hp. steam turbine. Each tanker contains three main cargo pumps like the one pictured at the left. It is an Ingersoll-Rand unit rated at 2000 gpm. against a head of 280 feet. The cargo pumps are located in a cofferdam between the aftermost oil tank and the engine room. The 200-hp. motor that drives the pump shown is in the engine room on the opposite side of the bulkhead at the right. This separation is made as a precautionary measure against fire hazard.

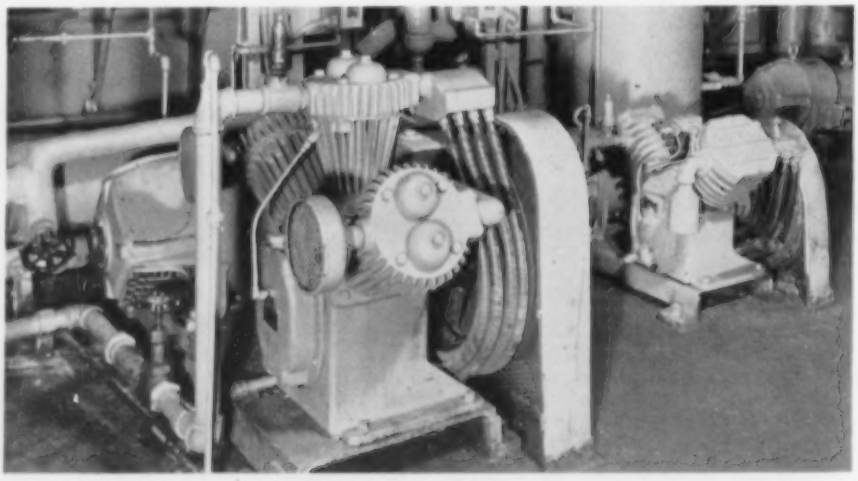
with their many valves and fittings and providing data for ordering the materials for them so that they will be on hand when needed. It makes diagrammatic drawings of these systems, which are the basis of working drawings used later in the work of installation.

Putting together the thousands of pieces of steel—large and small—that have been made ready in the yard shops, or been furnished by outsiders, takes place on the shipway. Hull construction engages the attention of many kinds of craftsmen, among whom are erectors, regulators, ship fitters, tackers, burners, and welders. The erectors' job is to get all the parts on the ship at the proper locations, and when they are required. The regulators and ship fitters square them up; that is, see that they are in correct position with respect to other connecting members. The reference lines that were mentioned in connection with the loft work divide the hull into a series of cubes, and as the parts are marked so are they positioned with accuracy by referring to these various division lines. Once in place, they are tack-welded or bolted and afterward completely welded. The ship fitters also do countless other things, and aiding them are the burners who cut holes, burn away excess metal, etc.

Meanwhile, as the hull rises, machinery is being put in place. Much of it goes in during the early stages of construction, when it can be lowered into position before overhead obstructions block the way. Here again it is necessary that each item be handled in proper sequence if all of them are to be fitted into the available engine-room space.

Then comes a day when a bottle of champagne is broken on the ship's prow and it slides down the ways into the Delaware River. Here, for the first time, it gets a name to replace the hull number. Tugboats quickly maneuver the vessel into a wet basin, where the work of outfitting continues. In a few days the tanker is ready for its trial run down the river 74 miles to the Delaware Breakwater. Members of the Maritime Commission trial board and Sun engineers, as well as representatives of many of the firms that have furnished power-plant machinery, make the run to conduct final tests.

The trial run, which in peacetime used to be a leisurely cruise to Rockland, Me., where deeper water is available, is now compressed into about 24 hours. Back in the wet basin, any operational shortcomings noted on the trip are corrected, craftsmen of many kinds again swarm over the ship to tackle the "unfinished-work list," and the ubiquitous painters follow after them with brushes and spray guns. In a few days more a crew comes aboard, mooring lines are hauled in, and the tanker departs without fanfare to take its place in vital war work, joining the many others that have slipped down the ways at the Chester yard. Their number is now so great that the company proclaims in its advertising slogan, "The sun never sets on Sun ships."



AIR COMPRESSORS

Each wartime Sun-built ship gets its compressed air from two Ingersoll-Rand air-cooled compressors such as those shown here. The near one supplies air for general ship service, including the operation of tools and engine-room recording instruments. The other machine furnishes combustion air for the oil-fired boilers.

Official U. S. Navy photos

ROMAN CANDLES OF DEATH

A blazing screen of antiaircraft fire raised against Nazi bombers when our ships were in action outside Algiers during the Mediterranean campaign. The picture below shows triple-gun batteries in the forward turret of one of our battleships firing 14-inch projectiles in the waters off the Aleutians.

Smokeless Powder for Our Navy

Robert G. Skerrett

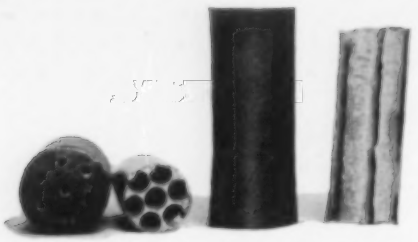
SMOKELESS powder is the propellant upon which our battling Navy relies to make its guns of all calibers far-reaching and hard-hitting, and it is substantially true that smokeless powder contributed more than anything else towards the development of the big rifles that have done such staggering work against our present enemies whenever and wherever our battlecraft have measured strength with them.

Smokeless powder should therefore be of more than passing interest to us because of the prime part it is taking in carrying us onward toward victory. We are indebted to the chemist for that propellant; but it took long years of research to make it possible for us to discover its controlling secrets and to arrive at a formula that would give it its splendid and virtually uniform performances under all service conditions. In various ways, our smokeless powder is a chemical paradox because of the inherent contrariness of some of the ingredients that enter into its composition.

The Navy's smokeless powder is evolved from guncotton as a base, and guncotton is a product of harmless cotton filaments that become highly explosive when dipped in nitric acid. Let it be recalled that it was guncotton with which the war heads of our torpedoes and our submarine mines were charged for years for the purpose of ripping the underbodies of hostile warships and blasting their vitals. And yet, it is just this tremendously quick-acting explosive that the chemist has found ways to tame and to bring under such control that, in the form of smokeless powder, it can be fired safely in our guns while, pound per pound, giving far better results than the black gunpowder that served battling nations for something like 600 years before substantial changes were made in that historic propellant. How long the Chinese had gunpowder at their disposal is not known, but the records show that they used it in warfare about 1232 A.D.

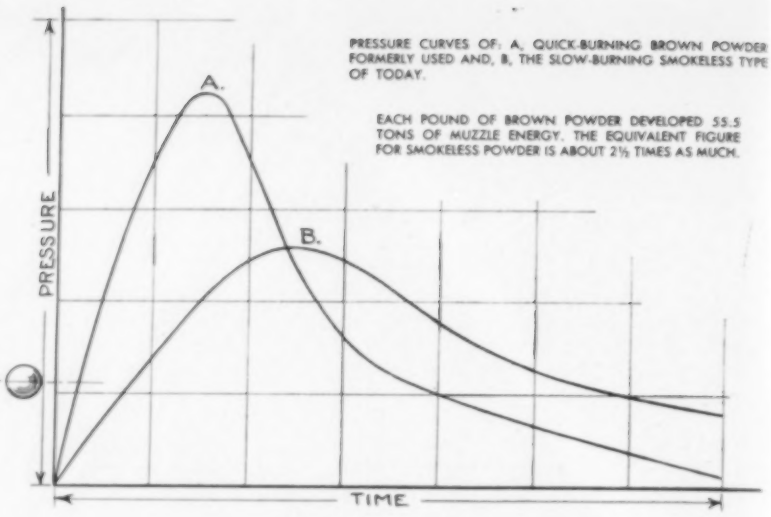
Nitrogen, in the form of saltpeter or Chilean nitrate, has always been indispensable in the manufacture of black gunpowder, which is composed of 75 parts of saltpeter, 15 of charcoal, and 10 of sulphur. The only variation occurred when brown powder was developed, the change in color being due to the utilization of charcoal obtained from underburnt straw. The propellant was otherwise modified by increasing the proportion of saltpeter and decreasing the sulphur content 2 or 3 percent while adding a new ingredient—a small amount of sugar.

The ballistic properties of brown powder were somewhat superior to



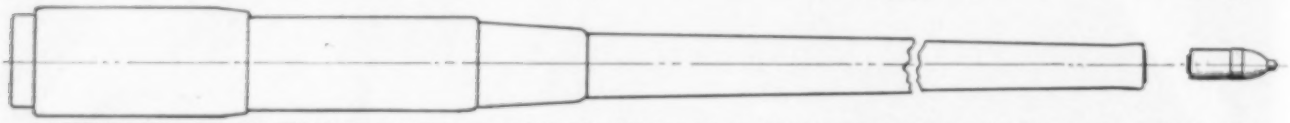
SMOKELESS POWDER GRAINS OF IDENTICAL SIZE BEFORE AND AFTER PARTIAL COMBUSTION. OUTSIDE DIMENSIONS ARE SMALLER, WHILE INTERNAL PERFORATIONS ARE LARGER AND OFFER MORE SURFACE FOR FLAMES TO GENERATE GREATER VOLUMES OF PROPULSIVE GAS.

THE 15-INCH CAST-IRON GUNS USED ON OUR LARGEST MONITORS SOME YEARS AGO WEIGHED 18.7 TONS AND FIRED A 450-POUND SOLID BALL WITH 100 POUNDS OF BLACK POWDER AT A VELOCITY OF 1600 FEET A SECOND.



PRESSURE CURVES OF: A, QUICK-BURNING BROWN POWDER FORMERLY USED AND, B, THE SLOW-BURNING SMOKELESS TYPE OF TODAY.

EACH POUND OF BROWN POWDER DEVELOPED 55.5 TONS OF MUZZLE ENERGY. THE EQUIVALENT FIGURE FOR SMOKELESS POWDER IS ABOUT 2½ TIMES AS MUCH.



A MODERN 12-INCH NAVAL STEEL RIFLE WEIGHS 53.4 TONS AND, AT EACH DISCHARGE, FIRES 353 POUNDS OF SMOKELESS POWDER TO START ITS 850-POUND ARMOR-PIERCING EXPLOSIVE SHELL IN FLIGHT AT AN INITIAL VELOCITY OF 2800 FEET A SECOND

those of black powder, and some of the betterment was attributable to the manner in which the "grains" were made and in which they were arranged in the powder bags. Each of the large grains was a hexagonal prism that was produced under pressure and perforated by one or more axial holes which, when the grains were properly packed in the bags, provided continuous passages through the charge for the flames of combustion. It has been authoritatively stated that the unusual composition of the propellant and the form and arrangement of the grains caused the mass to burn slowly and relatively progressively, thus increasing the volume of propulsive gas and inducing a steadier acceleration of the projectile as it was driven muzzleward. To this extent the action of brown powder differed from the abrupt and explosive action of black gunpowder. These facts should be kept in mind in order to evaluate the advance typified by smokeless powder.

There are some other things that should be known about the two older powders—things that inspired the quest for a more efficient and economical propellant, even when costing more per pound. When either black or brown powder was fired in a gun, only 35 percent of its weight was converted into the desired propulsive gas. The remaining 65 percent left the weapon mainly as dense smoke, while a part of the charge took the form of a solid residue that fouled the bore. Therefore, the 35 percent that became propulsive gas had to move the projectile as well as the smoke and any solid matter that was blown from the muzzle. The obscuring smoke was at times very hampering to the gunners; but smokiness was only one of the shortcomings of the older powders, for there still remained reduced propulsive efficiency, 65 percent of waste, and the stowage and handling of much material that performed no useful service. Such is the record of the gunpowders with which battles were fought over a period of centuries before smokeless powders, after various failures and disasters, reached their existing excellence.

Guncotton was produced in 1845 by C. F. Schoenbein, a German physicist, who rediscovered the fact that a smokeless explosive is obtained when pieces of cotton are dipped in nitric acid. While keeping his process secret, knowledge of the transformation worked leaked out and set ordnance experts agog. Later, General von Lenk, an Austrian, tried to use guncotton as a propellant in field guns, but the results were disastrous. Nevertheless, the work of those pioneers stimulated recurrent efforts to produce a better powder, and military men realized that the long-desired goal was nearer even though much would have to be done in mastering the uncertainties and the violence of nitrocellulose. However, years were to pass before acceptable propellants were produced.

The U. S. Navy did not take up its smokeless-powder quest until the "eighties" of the last century. Its pioneer work was done at the Naval Torpedo Station, Newport, R. I., where it had a small plant engaged in manufacturing guncotton for submarine mines and automobile torpedoes. The men most intimately identified with the years of intensive work involved were Lieut. John B. Bernadou and Prof. H. F. Brown, a chemist—both of whom were inspired by what had been achieved by Prof. D. I. Mendeléef, an eminent Russian chemist, who had discovered that cotton of relatively low nitration offered definite advantages as a base for smokeless powder. With that in mind, they conducted their experiments with guncotton having a nitrogen content of 12.44 percent. This was found to be solvent with a suitable mixture of ethyl alcohol and ethyl ether and to yield a colloid that could be formed into durable "grains" meeting the requirements of a propellant for naval guns. But the investigators had thousands of experiments and service tests to make before the path ahead was reasonably free of obstructions. Some of the powders were exposed to heat for a number of weeks and then fired to show that they had lost none of their ballistic qualities the while.

In 1897 researches were still going on, although the Chief of the Bureau of Ordnance reported that there had been turned out at the Naval Torpedo Station "a special variety of nitrocellulose soluble in ether alcohol, forming a colloid of extreme toughness that burns progressively in a very regular manner and which may be converted directly into a smokeless powder decomposing wholly into gaseous products, and possessing a high ballistic efficiency." The same year Congress provided money for the establishment at Indian Head, Md., of a naval smokeless powder plant large enough to supply the entire fleet. The better part of two years was spent in building and equipping that factory and getting it into production at the rate of 1000 pounds a day. Therefore our heavy

ships were still using brown powder when they defeated the Spanish fleet at Santiago, Cuba, on July 3, 1898. However, in 1901 the plant doubled its output, and thereafter was enlarged from time to time until, by 1917, it was making 20,000 pounds daily. By the end of 1941 it was producing still larger quantities of superior smokeless powder, thanks to important technical improvements and to advances in manufacturing processes and machinery.

Although it is not permitted for reasons of national security to describe in detail just what is done at Indian Head, the public can be given a broad understanding of how harmless cotton fibers are transformed into a high explosive; worked up into a chemical composition —not a mechanical mixture like black or brown gunpowder; and converted into so-called grains that range in size from bits of straw to pieces as large around and as long as a man's thumb. These grains burn progressively and are wholly consumed before the projectile impelled by them leaves the muzzle of the weapon. What is even more important to the designer of guns, the maximum pressures developed by the smokeless powder are lower than those of the older propellants and yet they accelerate a projectile so that it leaves any one of our high-powered rifles at a velocity far greater than was attainable when we fought the Spanish-American war.

Today, with our vastly increased battle fleet armed with innumerable guns for many kinds of service and all of them using an immense quantity of powder in the course of a single vigorous action, the need of an ample supply of prescribed high quality should be self-evident. Of course we have to rely upon private firms for a large percentage of our requirements, and what is done at Indian Head is fairly indicative of the steps by which these cöoperating concerns do their work. Some years ago, when the world was at peace, the Navy Department made public the following table giving the weights of the battle charges for the weapons then aboard our ships:

1-pounder	85	grams
3-inch 50-caliber	4.25	pounds
5-inch 51-caliber	27	"
7-inch	62	"
12-inch 50-caliber	353	"
14-inch 50-caliber	480	"
16-inch 45-caliber	600	"
16 inch 50-caliber	720	"

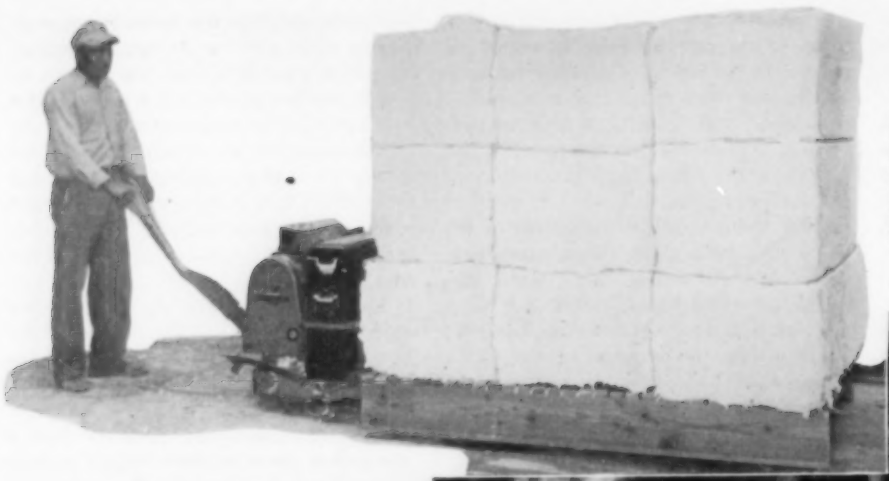
In the past, the cotton used in making smokeless powder was often the white waste from textile mills, but now only linters—the short fibers from cotton seed after the raw material has been ginned—are utilized. Before the fiber can be nitrated it undergoes treatments that clean it and free it of any foreign matter that would adversely affect the nitrated product. At Indian Head the cotton arrives in compact bales and is broken up by running it between toothed rolls that tear and shred the stuff so as to expose all the fiber surfaces to the action of the nitrating acids. Next it is given an alkaline bath, and then the water is removed for the most part by mechanical wringers. Following this, the cotton goes to the drying house where it is spread on a belt conveyor of coarse-meshed galvanized-iron screen on which it is moved slowly in the sweep of air currents heated to 210°F. Passage through a drier takes about twelve minutes, and the hot, dry air absorbs all but about 1 percent of the moisture content.

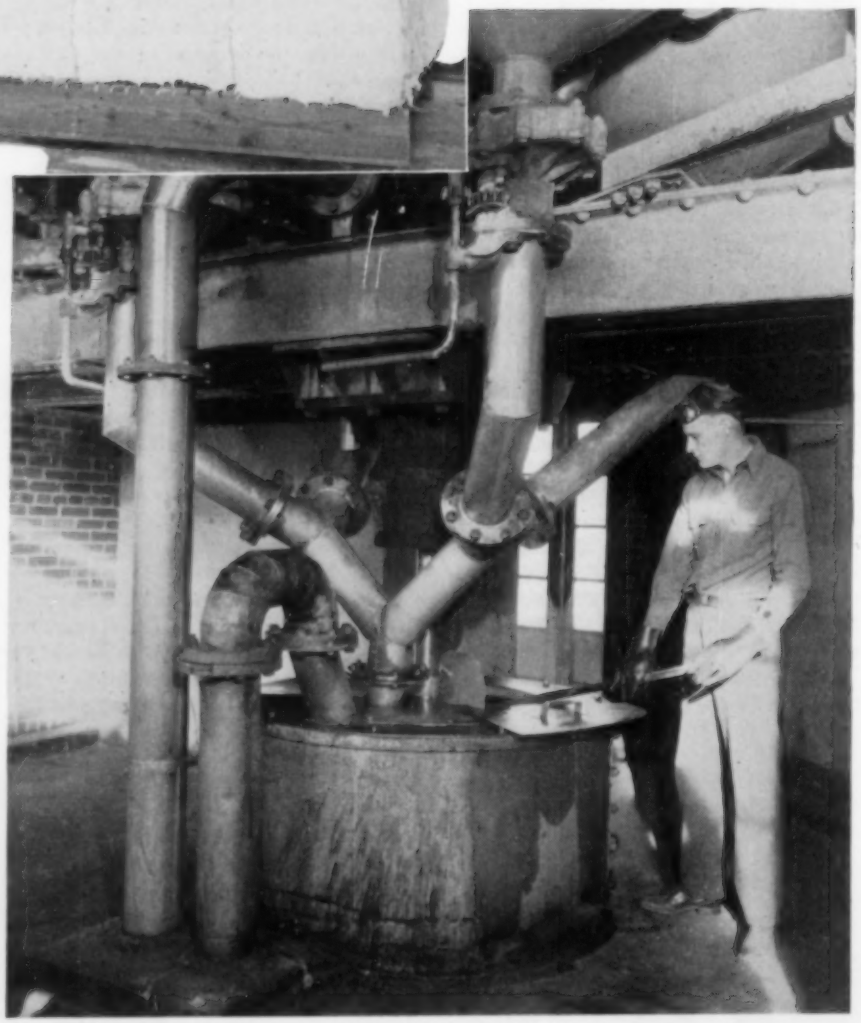
The reasons for the drying are thus explained officially: "The acids used for nitrating are very concentrated, and the heat of dilution, at these concentrations, is sufficiently great to cause excessive temperature rises and possibly fires if the cotton contains more than 1 percent of moisture. Further, the concentrations of the acids are very important from the standpoint of the nitrogen content of the nitrated product. Therefore, unless the cotton is dried to a definite reproduceable moisture content, the nitrogen content of the product cannot be predicted accurately nor controlled within the necessary limit." The acid mixture used in the nitrating house is a combination of nitric acid and sulphuric acid. The latter serves merely to absorb all moisture set free from the cotton through the action of the nitric acid, and in so doing the nitric acid is left with the strength necessary to do its full work of transforming the cotton into an explosive.

Before the dried cotton goes from the drying to the nitrating house it is packed in airtight flasks each holding 30-odd

PASS THE AMMUNITION

Enlisted men (below) in a human chain loading ammunition aboard a warship. The shells are in protective casings. The other picture shows rows of heavy shells on the deck of a battleship just prior to the assault on Guam Island.





POWDER FROM COTTON

A truckload of baled cotton linters (left) as taken from storage preparatory to undergoing the treatment that transforms it into smokeless powder. Shown below is a nitrating pot with connections for delivering the acid and removing the caustic fumes.

pounds, or just enough to be handled in a nitrating pot charged with 1600 pounds of the mixed acids, which have a temperature of about 87°F. Revolving paddles thoroughly agitate the cotton and the acids for twenty minutes, and that action converts the harmless fibers into nitrocellulose containing approximately 12.6 percent of nitrogen. Thereafter the material is known as pyro, in the vernacular of the powder plant. From the nitrating pot it is shifted to a centrifugal wringer which frees the new-born explosive of much of the excess acid mixture clinging to it. So recovered, the spent acids are returned to the mixing plant where they are fortified—brought again to the required strength—for reuse in the nitrating house.

After wringing, the pyro is doused in a tank of fresh water to rid it of more of the acids adhering to it. This is done lest the nitrated cotton take fire through the continued action of any free nitric acid still in contact with it. Combined with water, it is next pumped to large cylindrical, wooden vats in which it is boiled for 40 hours during which the water is changed five times to dilute and to get rid of most of the alkali used at the beginning of the treatment. From the boiling tubs the stuff goes to the pulping and poaching house in which it is run through a Jordan pulper and macerated by knives to further assist the purification processes. Placed in poaching tubs with a capacity of more than 3.5 tons each, the pyro is boiled for eight hours with four changes of water and then undergoes eight cold-water washings. Virtually all the work done in the pulping and poaching house is a counterpart of the way wood pulp is treated in a paper mill preparatory to running it through the rolls of a paper-making machine.

From the poaching tubs the explosive is pumped to the dehydrating house, following a screening operation that removes any coarse material. In this plant excess water is got rid of by centrifugals that leave in the pyro about 30 percent of its moisture content. Prior to this processing, the material has been tested to make sure that the last trace of the nitrating acids and of the alkali added subsequently have been removed. At this stage the stuff has the feel of damp bread crumbs. Final dehydrating is done in a hydraulically operated, specially designed press that consists of a vertical cylinder equipped with two pistons or rams that move up and down from opposite ends of the cylinder. The procedure is as follows:

The bottom piston is lowered and the upper one is raised so that a charge of 50 pounds of pyro can be dumped into an interposed "basket." That done, the upper ram is lowered to form a tight seal on top of the basket, after which the bottom ram is raised and exerts a pressure of about 250 pounds per square inch against the pyro. While this pressure is still applied, alcohol is pumped through ports in the cylinder into the compacted material at a pressure of 500 pounds. The ports are then closed, and a pressure of 2000 pounds is exerted for a definite time—the combined action of pressure and alcohol serving to expel the last of the water, while a carefully controlled percentage of alcohol remains in the "block" or cake which has a nitration of something less than 12.7 percent. The pyro is not yet a colloid, and will not be until ether is added to the alcohol to produce the necessary solvent that will work the change from nitrocellulose to pyrocellulose that can be formed into smokeless-powder grains. Neither alcohol nor ether alone will do the trick—such being one of the mysteries of chem-

ical action. It may be of interest to know that smokeless powder is really a brother of collodion so useful in medicine and photography, while celluloid, with its endless applications, is a first cousin and lies just beyond the dividing line of substances soluble in ether-alcohol.

Upon its removal from the hydraulic press, the alcohol-saturated cake is placed in a sealed metal tank for transfer to the mixing house where it is broken up into a granulated condition. The ether is produced by the action of sulphuric acid on alcohol at a temperature of 266°F. and is added, together with a proportionate amount of diphenylamine, at the rate of ½ pound for each pound of the damp pyro. The mixture then goes into a rotating drum for about half an hour, and there, through the action of the ether and alcohol, it becomes partly colloided. In this state the material is shifted to a press to again be formed into a cylindrical block preparatory to taking it to the press house. At this stage the operatives are dealing with smokeless powder in the rough: the next steps shape it into the grains needed for each size and type of gun carried aboard our combat craft. And let it be emphasized here that this matter of dimensions of powder grains is of prime importance.

In the old days, when the Navy used black and brown powders, the ordnance engineer had to design his guns to meet the decidedly violent actions of those propellants. The weapons were relatively short and notably bulky around their breeches—tapering somewhat sharply toward their muzzles. Today he plans his rifle to give definite ballistic results, and the entire body of his gun, caliber for caliber, is much longer than formerly and conspicuously slimmer in its modeling. This is because smokeless powder is made to meet the requirements of the weapon; and to this end, the space, the dimensions, and the number and arrangement of the longitudinal perforations in each grain are carefully predetermined. These niceties regulate the rate and the total volume of propulsive gas evolved by the powder during its combustion, which must be completed while the projectile is moving to the muzzle. The smoothness of this progressive action depends upon the way in which each powder grain is consumed by the enveloping flames under the pressure of the gas. As the exposed surfaces of a grain, layer by layer, are burned away both outside and in the longitudinal perforations, the interior area is increased as the exterior area is reduced, and thus is maintained a compensating and well-balanced generation of propulsive energy. In this respect the action of smokeless powder differs in a marked degree from that of the older powders.

In the press house the bulk smokeless powder is given the desired granular form for each type and size of gun. The fresh colloid is first macerated to break up any hard lumps that may remain in the material, this being necessary because there are variations in the cotton fiber from different sections of the country. In substance, the powder in its final state must be uniform throughout to insure the smooth and balanced action demanded both for safety and for the high standard of performance expected of each gun in which the powder is to be fired. After maceration, the colloid is compacted in a hydraulic press and formed into cylindrical blocks that have the consistency of natural crude rubber and are much like syrupy maple sugar in appearance.

To give the colloid a still more thorough mixing, the amber-colored cakes are reblocked under pressure and forced through sturdy steel colanders from which they issue in slithering, cream-colored, solid cords. After that, to attain the desired degree of uniformity, they are packed into the cylinder of a block press and reshaped into cylindrical units which are loaded into a die press and subjected to pressures ranging from 4000 to 6000 pounds, depending upon the size and shape of the grains into which they are to be made. The extruded colloid is in the form of flat ribbons or in concentrically perforated cords that are chopped by mechanically operated knives into grains of any required length. From there on the "green" powder grains undergo various treatments that finally result in a suitably dry and seasoned product that attains a hornlike hardness and a color ranging from amber to deep brown.

PROCESSING STEPS

The nitrated cotton, called pyro, is dehydrated in the hydraulic press shown at the right. As pressure is applied, alcohol is forced through the cake to expel moisture. Afterward, the cakes are broken up in mechanical mixers (above) preparatory to receiving ether which, with the alcohol already in the pyro, converts it into a colloid.

FORMING THE POWDER

A block of pyrocellulose is placed in a press (upper left) to be converted into a perforated rod of smokeless powder of the desired diameter (above). The latter is then cut into pieces or grains (upper right).

The green powder contains a considerable excess of ether-alcohol solvent, particularly ether, which is highly volatile. In the course of the different processes through which the green powder is run, much of this ether evaporates and is withdrawn from the various working points by suction ducts. The air from these ducts is blown through activated carbon from which the volatile solvent can be extracted and made available for reuse. This system more than pays for itself through the ether reclaimed, but the main reason for the installation is the health and safety of the operators. There is, however, a solvent-recovery process *per se* that is used immediately after the newly formed powder grains come from the cutting house and are placed in large tanks through which air is circulated to remove the solvent to the degree prescribed to give the powder a specified ballistic performance when fired. The system usually is a closed one, and inert gases are employed with the air to reduce explosive hazards. The air-and-gas mixture is heated, passed through the powder, cooled by refrigeration to condense and precipitate the solvent, and then reheated for use again. Enough of the solvent must remain in the powder to check any tendency to burn too quickly in a gun and so develop undesirably high pressure. It is after the removal of the excess solvent that the powder grains become hard, tough, and more or less translucent.

As the performance of a charge of smokeless powder is influenced by the physical perfection of all the grains, the green powder is carefully hand-picked to rid it of any grains that differ in size, form, or otherwise from specifications. The approved grains are carried to one of several large dry houses where they are held for about 60 days at air temperature and then exposed for two to four months to circulating air maintained at 104°F. In some plants the explosive first undergoes a water-drying treatment by which it is subjected to a higher temperature than in the case of air-drying. It is said that the use of the two processes shortens the time required to bring the propellant to the dryness desired.

All powder produced from a given lot of guncotton received from the poaching plant constitutes a "lot," and a careful record of it is kept not only through all subsequent steps of manufacture but until it is expended in service or returned to Indian Head for reworking into good powder for reissue. Samples of each lot are stored there in surveillance magazines under conditions closely corres-

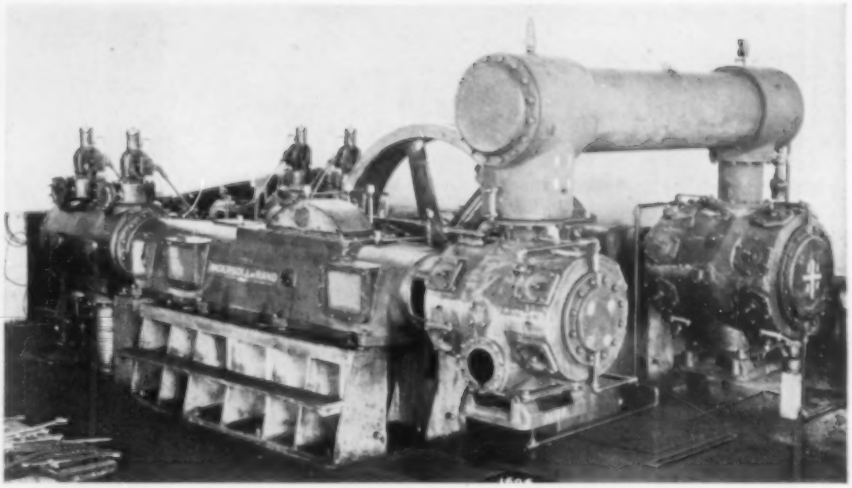
ponding to those prevailing in magazines at shore stations or on shipboard. Furthermore, chemists make regular examinations and tests and are quick to detect any signs of deterioration or change that indicate that the propellant should be sent back to the smokeless-powder factory for reworking—the shore magazines or the ship or ships concerned being promptly notified.

In the earlier years, the smokeless powder produced for the U. S. Navy did not always perform uniformly even though every lot had been put through its paces at the proving ground before being shipped in airtight metal tanks. In one case, $40,000 worth was dumped overboard from a ship on a foreign station because her ordnance officer reported his doubts about its stability. Since then our smokeless powder has been brought to outstanding excellence and prolonged stability partly through the controlling effect of the chemical diphenylamine. We have to face the fact that smokeless powder is a chemical product which undergoes chemical alteration in time, and one of the ways of minimizing this, even with the use of the stabilizer mentioned, is to blend all the grains made from a given lot of raw materials so as to contribute towards high average uniformity.

Grains of smokeless powder may be exposed to considerable heat before they will ignite, and then they burn with a bright flame and smokelessly in the open air. They may even be hammered and otherwise mishandled without exploding. In short, smokeless powder is classed among explosives as "slow-burning." But when it is ignited in the confined space in a gun, combustion is rapid, and that rapidity is augmented by the increasing pressure of the flaming gas. But the propellant is not in fact smokeless, as the discharge of a large gun gives impressive evidence. What one sees is a swirling dark-brown cloud that is produced by the sudden release into the air of highly heated gases in which is mixed the smoke from the black powder that has to be used as an igniting charge to start all the smokeless-powder grains burning. Even so, the cloud obscures a target only for a few seconds.

No substitute has yet been found that is as satisfactory as black powder for the ignition charge, which is attached at the bottom or rear end of the assembled bags that make up the unit charge at each firing of any of our rifles that are too big for fixed ammunition such as is used for rapid-fire guns. Thus powder with an ancient lineage prods the new and modern propellant into action. But black powder is also employed for saluting purposes, where its cloud of white smoke, like a great waving handkerchief, is a military courtesy that subscribes to tradition.

The grains of smokeless powder are packed in bags of special silk cloth sewed with silk thread and reinforced by a lacing of silk cord. The ignition pockets each carry a small charge of black powder and are also fashioned of silk fabric but of lighter weight so as to make the explosive more accessible to the electric spark that ignites a small charge of dry guncotton which, in turn, detonates a cap of fulminate of mercury that sets off the black powder, the igniter of the smokeless powder. The sequence just mentioned is accomplished in an amazingly short period. Formerly the powder grains were packed in a bag just as they fell; but in the case of the larger grains it has been found that better results are obtained when they are stacked end to end and arranged symmetrically about the axis of the bag. There are machines that do this stacking.



POWER-RECOVERY COMPRESSOR

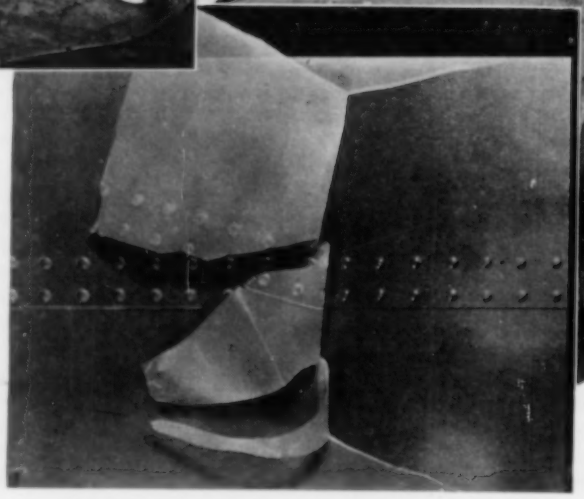
In manufacturing the nitric acid required in making smokeless powder, fixed nitrogen and hydrogen, under pressure and at high temperature, are brought in contact with a catalyst to produce ammonia. From the latter, nitric acid is obtained by oxidation. This reaction gives rise to some waste gas at 90 pounds pressure which is used in the power cylinders of one of the compressors employed in the first stage of the process. In the case of the machine shown, the energy recovered and made to do useful work amounts to 372 ihp. The compressor was photographed while assembled for preshipment tests in the factory where it was built.

Probably nothing more strikingly illustrates the changes that have taken place at Indian Head over the years than the plant now in operation there for the fixation of atmospheric nitrogen which provides the nitric acid required to produce guncotton for our smokeless powder. During the short while the United States participated in World War I, the Navy was confronted with a shortage of nitric acid, as were other powder makers throughout the country, and the disruption of shipping made the importation of nitrate of soda problematical. Money was provided and feverish steps taken towards erecting and equipping close to Indian Head a plant capable of making daily 115,000 pounds of nitric acid. By the manufacturing process that was to be used there, fixed nitrogen and hydrogen were to yield ammonia—as a basis of nitric acid—by direct synthesis, by passing them under pressure and at high temperature over a suitable catalyzer. The estimated cost of the project was $9,150,000, and the contract was let to J. G. White Engineering Company in conjunction with the General Chemical Company.

The undertaking was a decidedly new one for us, and circumstances made it impossible to carry it out. The subject was later revived, and today we have on the Potomac just such a plant drawing nitrogen from the free air and providing from that inert gas the very acid that is needed to transform cotton fibers into the basic explosive for smokeless powder. E. I. du Pont de Nemours & Company saved the situation in 1918 by planning and erecting sulphuric and nitric-acid plants at Indian Head in ample time despite unusual difficulties and also has contributed to the success of the plant for the fixation of atmospheric nitrogen now in service.

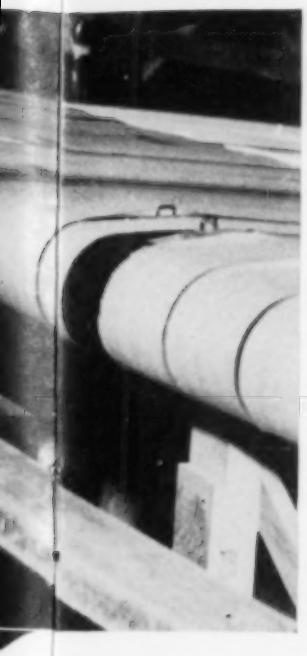
The large compressors in the fixation plant are unique and the outcome of intensive experimenting. They supplement other compressors at that station which furnish air for many helpful uses such as the handling and distribution of acids and of other liquids and semifluid materials. Over the years since the powder plant was established at Indian Head there has been close and cordial collaboration between the Navy and the commercial producers of explosives and special machinery, and out of this give and take the Navy has benefited to the advantage of the nation, as has been proved by the magnificent performances of the guns aboard all our battlecraft.

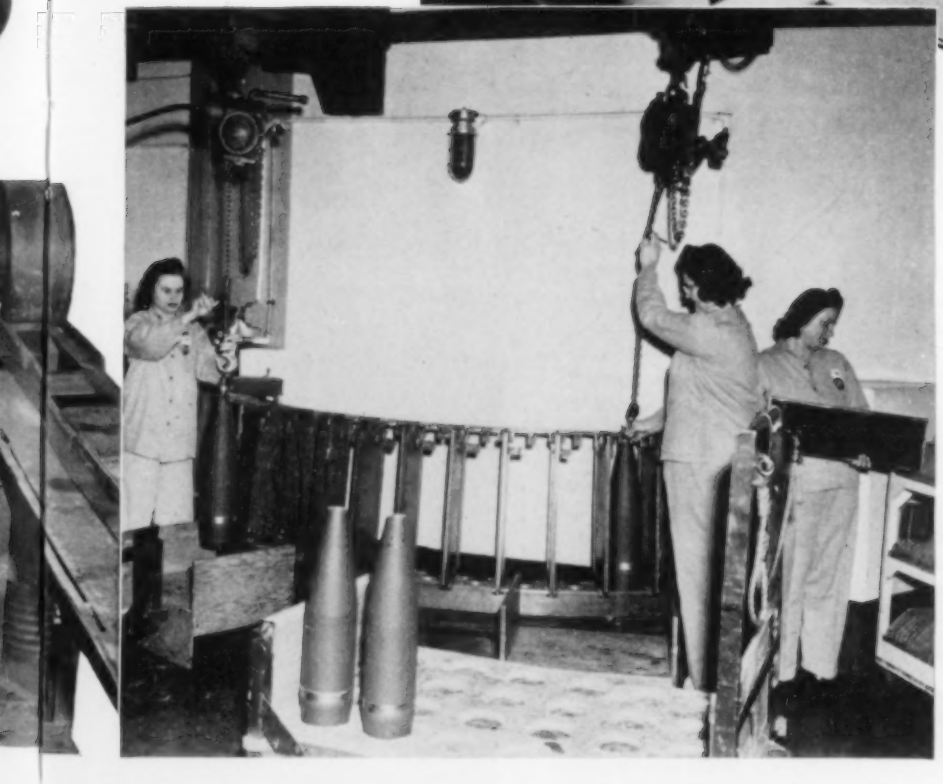
THE machine pictured at the right is an electronically controlled air doffer in a Massachusetts laundry. It doffs or removes pillowcases from a conveyor to which they are delivered after passing through a large ironer. As the cases move along they interrupt a beam of light, and this sets the mechanism into action. When they pass this zone, the unobstructed beam strikes a photo-electric tube, causing a solenoid valve to open for 3/10 second and allowing compressed air to enter two horizontal, perforated tubes that are visible just below the end of the conveyor. Air from one tube strikes the leading edge of each pillowcase, and the streams issuing from the other blow toward the lagging end, lifting the article and laying it across a horizontal bar. The pillowcases are stacked on the bar until an attendant removes them.



MANY airplanes that are shipped overseas are protected against moisture, dirt, and grease by a paper-thin coating of plastic solution that is sprayed on with an airbrush (above). Upon the craft's arrival at the delivery point, the film is stripped off (right) and the plane is ready for action. The plastic is a vinylite resin produced by the Bakelite Corporation. Suggested postwar uses for it are the packaging of numerous things from machinery to food and sensitive chemicals.

Compressed Air at Work





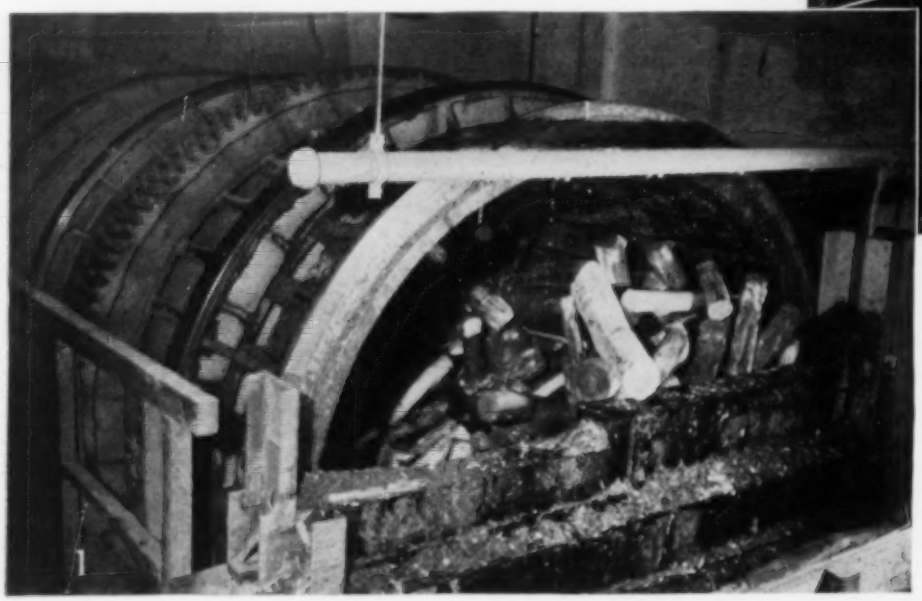
THE girl pictured above is checking the accuracy of the bore of a Pratt & Whitney aircraft engine bearing with the aid of compressed air. The gauging device functions by measuring the leakage of air past a standard mandrel inserted in the bearing. The flow is indicated on the gauge dials. Variations in diameter and deviations from roundness are quickly determined by this method. There is no danger of scratching or otherwise marring the finely finished surface, as might be the case when using other types of gauges.

AFTER 90-pound, 155-mm. artillery shells are filled with hot TNT at the Milan (Tenn.) Ordnance Center, they are X-rayed to detect cavitation, air bubbles, etc. They are carried into and out of the X-ray room by the motorized conveyor ring shown at the left. Two Ingersoll-Rand Air-bloc industrial hoists lift the shells on and off the traveling line, enabling girls to do the work without physical effort. A shell is placed on the conveyor at the left, occupying a cubicle that also contains a cassette of film that comes out of the X-ray room bearing a radiographic image of the shell and its contents. The shell and cassette are removed at the right. This equipment, which for the first time permits a loaded shell to be inspected without destroying it, was provided by the General Electric X-ray Corporation.

AT ONE of the plants of Dresser Industries, Inc., steel tire bases made for use on Army-tank bogie wheels were formerly lifted, placed over a fixed gauge to check the inside diameter, and then removed by lifting them again. As each piece weighs 46 pounds, the work was fatiguing and required the service of a man for each woman inspector. An employee suggested the air-operated gauge table (left) shown in use by the man in the foreground. At the turn of an air valve, the table rises from below the level of the work bench and stops with the gauge in correct position inside the tire base. After inspection, the gauge is lowered and the piece moved along the table to the next station.

PAPER-MAKING OPERATIONS

The making of book paper consists essentially of extracting cellulose fibers from wood, matting them together into a sheet, drying the latter, and imparting the finish that fits it for its intended use. These pictures show some of the major steps involved in the process. 1– Barking drum, where the 4-foot lengths of logs are debarked by abrasion. 2– One of the 86 beaters that separate and soften the cellulose fibers. 3– The wet end of a papermaking machine where the watery stock is fed onto an oscillating, traveling screen which supports it until enough water has been extracted to form a stable sheet. 4– The dry end of the same machine where the paper comes off onto a large roll which is then rewound and meanwhile trimmed evenly on the edges and cut in the center to form two strips. 5– Some paper is coated with very fine china clay and casein to give it a smooth, glossy finish. A brush coats one side of the strip as it is unwound from the roll, and other brushes distribute the wet coating evenly. The strip then moves on into a drying room. A returning strip may be seen overhead. Some machines coat both sides of the paper at once.



Making Book Papers

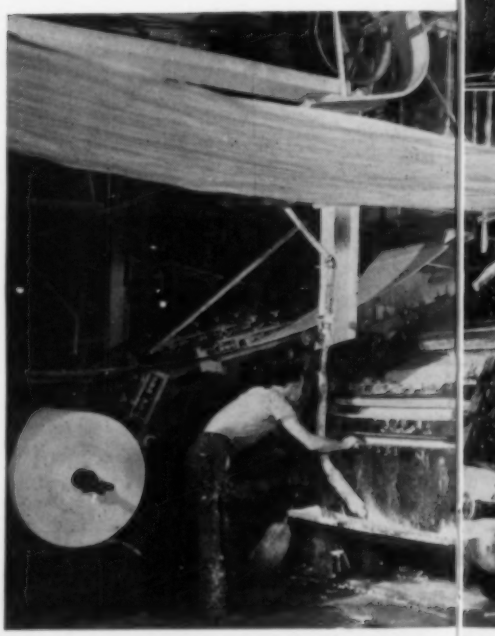
Allan W. Loomis

IT MAY interest you to learn that the paper in the book you are possibly reading and on which catalogues and magazines are printed is known to printers and papermakers as book paper. Such paper is also used for labels, leaflets, envelopes, lithograph work, rotogravure sections, maps, certain classes of wrappings, and for many other purposes having little relation to books other than the need of a definite type of high-grade paper going by the name of book paper.

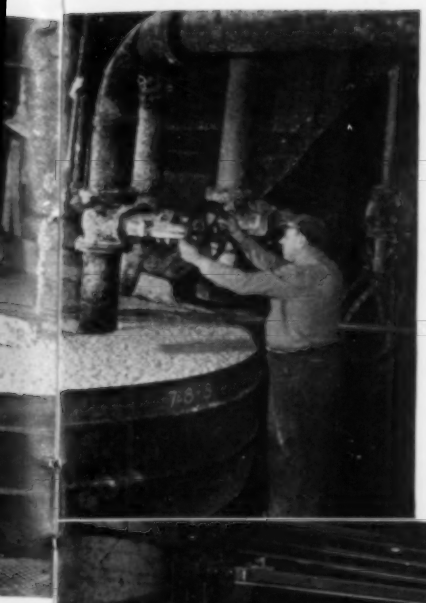
For years the Oxford Paper Company has been making fine book papers. The original mill was erected about 1900 at Rumford, Me., on the Androscoggin River; and as demand for the product increased, the plant has been expanded until its buildings now contain more than 25 acres of floor space. A smaller mill, located a quarter of a mile away on the same river and known as the Island Division, was acquired in 1936. It has an additional 14 acres of floor space. There is still another plant at West Carrolton, Ohio, which serves the company's customers in the Middle West.

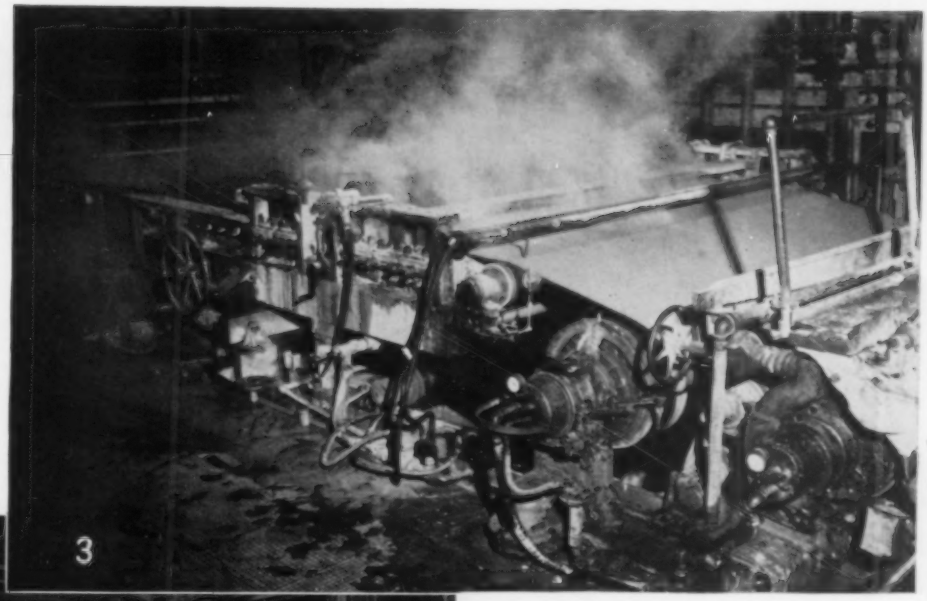
The mill at Rumford produces its raw material by two processes—by the soda process, which converts woods such as poplar, maple, beech, and birch to pulp by cooking the chips in an alkali liquor, and by the sulphite process which is used to reduce the wood of spruce, hemlock, and fir trees to pulp. The Island Division makes sulphite pulp and also some groundwood which, as the name indicates, is obtained by subjecting the logs to the rubbing action of huge grindstones. All three types of pulp—soda, sulphite, and groundwood —enter into the manufacture of the different papers produced at that mill. Fine book papers are made almost exclusively from a combination of sulphite and soda pulps. The former is long-fibered and gives the paper strength and endurance, while the soda pulp is short-fibered and is used as a filler to give the paper bulk and opacity.

The company maintains a well-staffed research department with headquarters at the Rumford mill. Members of this organization are continually experimenting with wood pulp produced by the various processes, even with those not in use at the mill. They also investigate sizing and coatings for paper, as well as possible modifications in the procedure by which the sheet is formed on the paper machine. The department thus pays for itself not only by improving the quality of the paper but also through economies effected in its manufacture.



The major raw material of book paper is wood, and there are ample supplies of spruce, hemlock, fir, poplar, and hardwoods available on nearby timberlands and on land owned and leased by the





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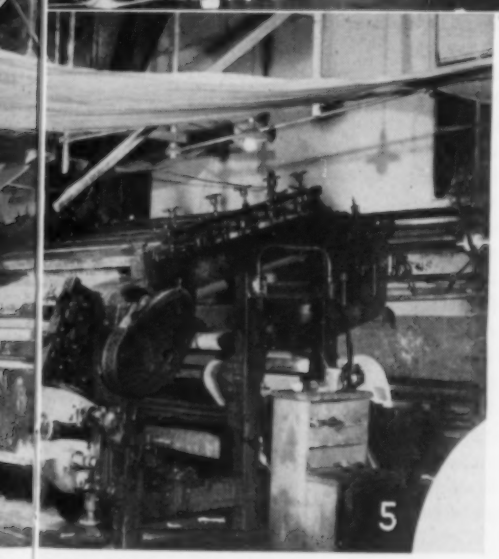

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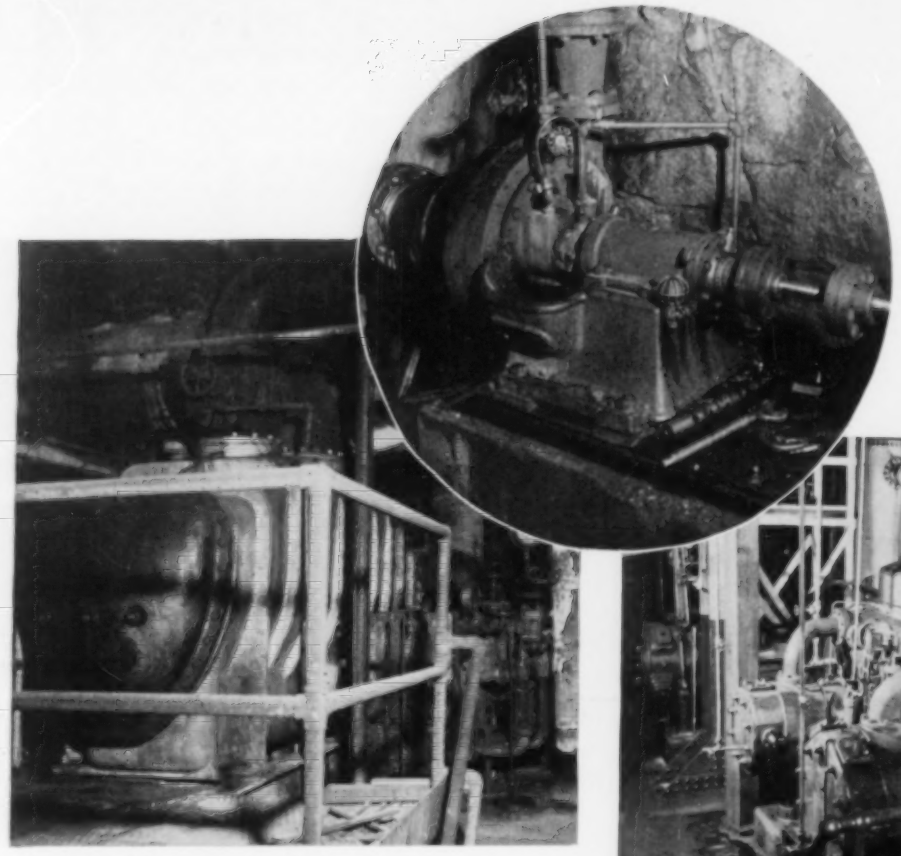
company in Nova Scotia, Canada. Their conversion into pulp and its subsequent formation into paper are complicated mechanical and chemical processes. Nevertheless, the transformation that takes place between the felling of a tree and the time a sheet of paper is ready to leave the plant is of absorbing interest. Suppose we follow some logs through the Oxford Paper Company's mill at Rumford. We will skip some of the operations, for otherwise our trip would be too long. Actually it takes at least a day, and sometimes many days, before incoming logs are shipped out in the form of paper. In fact some wood and some semiprocessed pulp is stored at the mill for months.

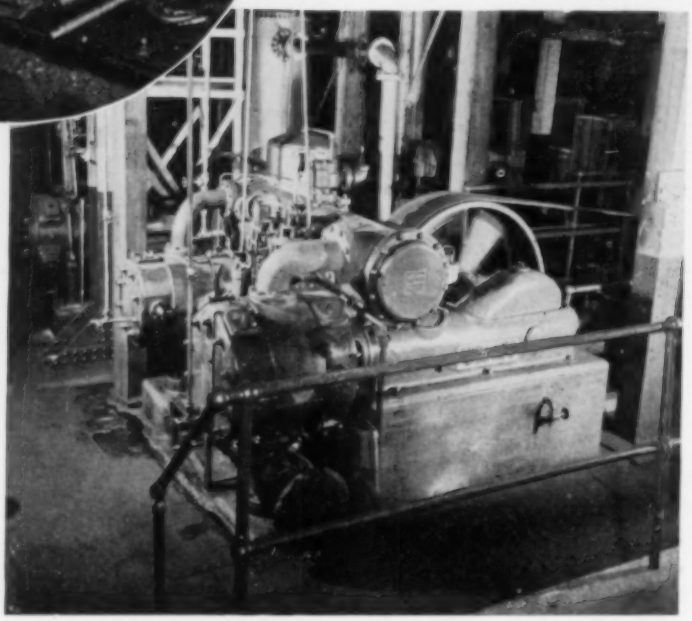
The timber is cut into 4-foot lengths in the forests and brought to the plant by truck or railroad. Because more logging is done during the winter months than in summer, it is necessary to keep large supplies available in the wood yard of the mill. At Rumford, this raw material is stacked in large cone-shaped piles at convenient places in the yard. From the latter, or direct from incoming trucks and railroad cars, the 4-foot logs enter the wood room where they are washed and cleaned. It is essential that all material not suitable for conversion into pulp be discarded there, otherwise the quality of the paper will suffer. Further, if the bark has not been removed from the wood in the forest, that work must be done in the wood room.

The debarker is a huge rotating drum which tumbles the logs against the sides and one another until the bark has been rubbed off. Upon the completion of this operation the wood is again washed. In addition to the barker, the room contains knotters for taking out knots, knife barkers, splitters for reducing the size of overlarge logs, and seamers for removing pitch and ingrown bark. The bark and other waste is carried from the wood room to a connecting building by a chain conveyor. There it is burned in a specially designed boiler, and the steam thus generated supplements that produced in the coal-fired boilers of the main power plant.

When the wood is thoroughly clean it goes to the chippers. These machines have knives mounted in the face of a heavy revolving disk against which the logs are fed in such a manner that the knives slice across the grain, cutting chips about ¾ inch long. These chips are screened to eliminate sawdust and fines and to separate oversize chips, which are sent to a crusher. The acceptable material is conveyed to storage lofts above the digesters. During all the necessary cleaning and processing operations in their progress through the barking drum and chippers, the different species of wood are kept separate—the chips of spruce, hemlock, and fir going to lofts above sulphite digesters, while those of poplar and various hardwoods are delivered to lofts above soda digesters.

The purpose of the digesters is to convert the chips into pulp which, when bleached, is essentially pure cellulose.





AUXILIARY MACHINERY

The alkaline liquor used in the soda digesters to treat wood chips is recovered after it has done its work, the process by which this is effected being known as the black-liquor recovery system. The solution is evaporated under vacuum in multiple-effect apparatus, the steam from the last effect going to the Ingersoll-Rand condenser shown at the far left. This unit, which is served by a 2-stage air jet, pulls a vacuum of about 25 inches of mercury during the final stage of evaporation. The black liquor is handled by the Ingersoll-Rand centrifugal pump illustrated in the center. One of the seven Ingersoll-Rand air compressors that serve the Rumford mill is pictured below.

Filled with chips, which are covered with a liquor, steam is introduced into the closed vessels to provide heat for the "cook," during which pressure and temperature are regulated over a period of several hours in a cycle which experience has shown produces the most satisfactory pulp. This pulp is the basic material from which the paper is made and goes by several names—pulp, stock, and, perhaps most expressive of all, stuff.

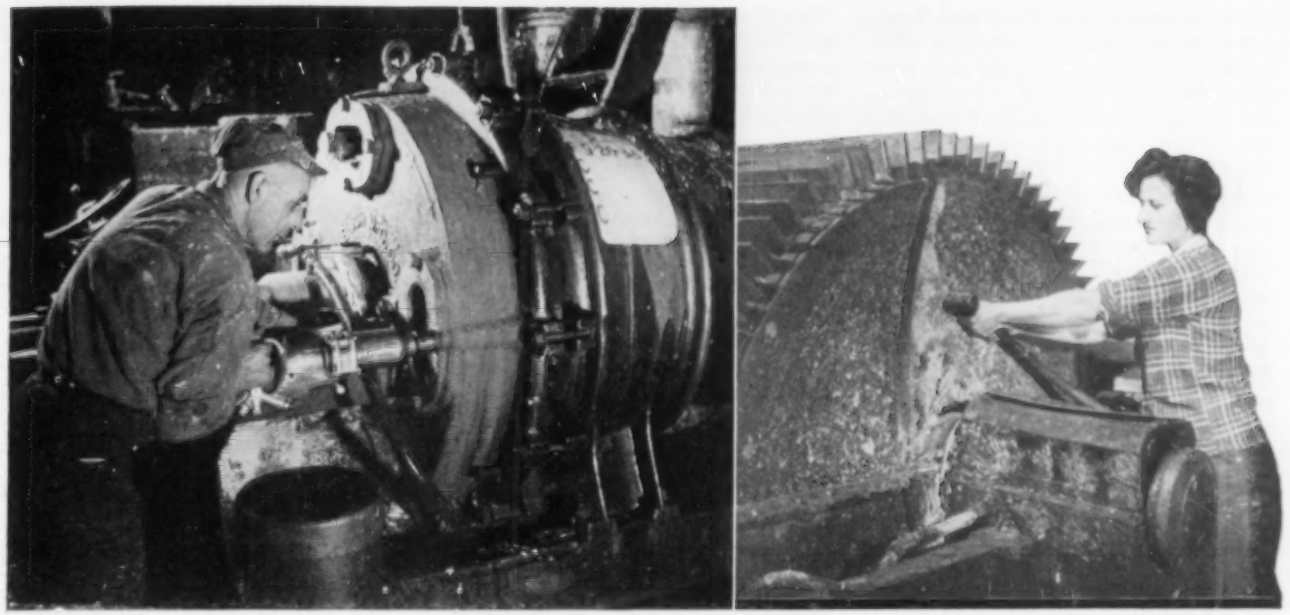
The digesters used are huge affairs. Those for the soda process are 9 feet in diameter and nearly 43 feet high, and a single charge for each consists of approximately 10½ cords of poplar or hardwood and 10,000 gallons of liquor. Cooking time varies with the type of wood and other factors, but is usually between 5 and 6½ hours. The liquor is an alkali—sodium hydroxide. It is continually circulated during the cook by a pump which takes liquor from the bottom of the vessel and sprays it on the chips at the top. An elaborate recovery process, known as the black-liquor system, reclaims a large percentage of the "spent" sodium hydroxide, and it is upon the efficiency of this recovery system that the economical operation of the soda process largely depends.

The sulphite-process digesters are 16 feet in diameter and about 60 feet high and each has a capacity of approximately 36 cords of spruce, hemlock, and fir wood and 46,000 gallons of liquid. Cooking time, as in the soda process, varies somewhat, but is in the neighborhood of ten hours. The liquor consists largely of bisulphites of calcium and magnesium and of sulphur dioxide in solution. It is produced in the plant by burning sulphur and by bringing the sulphur-dioxide gas thus formed into contact with lime-water. The relief gases from the digester also are reclaimed and reconverted into cooking liquor.

When the cook in either a soda or a sulphite digester is completed, the stock is "blown out" through a valve at the bottom. Since considerable pressure is built up in the vessel by the steam and by the gases developed during cooking, it is emptied in a remarkably short time. While the methods of handling the soda and sulphite pulps differ somewhat, the pulp, in each case, is separated from the cooking liquor, washed, screened to eliminate large or uncooked pieces, and bleached. After that it is washed again.

The Rumford mill produces its own chlorine for bleaching, and for this purpose has installed in a separate section of the plant nearly 300 electrolytic cells. The raw material used is common salt—sodium chloride. This is made into brine so it can easily be fed to the electrolytic cells. The anodes are graphite rods; the cathodes are mercury of which about 2 gallons, weighing more than 200 pounds, is circulated slowly on the floor of each cell. A current of 4 to 4½ volts serves to break up the brine into its constituent elements, sodium and chlorine. The latter is collected and combined with lime to make bleaching liquor, while the sodium forms an amalgam with the mercury and passes on to another compartment of the cell. There it combines with water to form caustic soda, which is required in the production of the cooking liquor that is used in the soda digesters.

Bleaching consists essentially of mixing the pulp with the liquor and heating it slightly through the addition of steam. The chlorine in the bleach releases the oxygen in the water and this serves to oxidize the fibers and to whiten them, care being taken so as not to impair their strength. After mixing, the stock goes to tile towers in which it is allowed to settle for approximately 1½



PNEUMATIC-TOOL APPLICATIONS

Nearly every type of pneumatic tool made is used in the mill, principally for maintenance work. The workman shown at the left is removing the head plates from a Jordan with a Size 514 impact wrench. A Jordan is a cone-shaped vessel in which the cellulose fibers are further separated and softened after leaving the beater. The young lady at the right is removing hardened paper stock from the end of a beater roll with an air-operated scaling tool.

hours. Next it is pumped to a soaking tower where aeration by means of compressed air aids bleaching. This entire process is then repeated, but with the use of less bleach, and when the pulp is of the desired degree of whiteness and purity it is washed and sent to storage tanks for transfer to the paper mill. Some of the bleached material is converted into "laps"—folded, rug-thick, moist sheets that are stored for use as needed. However, when pulp is to be shipped out of the plant, it is usually dried and rolled because it is lighter and easier to handle in that form.

It should be noted that the pulp produced by the soda process from poplar and hardwoods has so far not been permitted to come in contact with the sulphite-process pulp from spruce, fir, and hemlock, and that even where the two processes are essentially the same, the equipment used is different. The next step is that of beating, and it is then that all the components of a sheet of paper are brought together for the first time. The beater room of the Oxford Paper Company contains 86 beaters. These are oblong tubs, each some 11 feet wide and twice as long, divided lengthwise by a partial partition leaving a free passageway for the stock at each end. The beater roll extends halfway across the tank to the partition. It weighs several tons and, as it turns on its horizontal axis, moves the stock round and round in the tank, beating or crushing it between bars disposed circumferentially on the roll and similar fixed knives on the bed of the beater. There are about 80 such bars on the roll and half that number on the bed. Beating does a number of things to the pulp: it separates the individual fibers, makes them flexible, and reduces them to the proper length.

Each grade of paper requires varying proportions of sulphite and soda or other pulps and the addition of different sizes and fillers. Variations in the cook or in any of the other ingredients call for corresponding variations in the treatment of the stuff in the beater whose operation, together with the adjustment of the roll, is therefore largely a matter of experience. In most cases the stock remains in the beater for a period ranging from four to five hours.

From the beaters the pulp is fed to Jordans, another type of refiner that is designed to further brush or separate the fibers. This machine is cone-shaped and has a rotating center or plug equipped with bars or knives. The paper stock enters at the small end and, after being subjected to the action of the knives, is discharged at the large end. After leaving the Jordan, the stock goes to a storage chest where it is kept agitated until needed for use on the paper machine.

The conversion of pulp into paper is something of a miracle. There are twelve machines or Fourdriniers at the Rumford mill, and the largest of these can form a sheet 162 inches wide. The machines vary somewhat in length, but are in the neighborhood of 200 feet long. The first one-quarter section consists of a flow box, which distributes the stock, and of a moving wire screen on which the sheet is formed. This is known as the wet end of the machine. The next section is composed of suction and press rolls for sucking and squeezing moisture out of the paper. The entire final half is made up of heated drying rolls placed in two banks one above the other.

The pulp, on which so much care has been lavished, contains about 99.5 percent water when it is flowed onto the wire which, as a result of the combined forward and vibratory movement, distributes the stock and forms it into a sheet of interlaced fibers. In its journey, part of the water drains through the wire, some is withdrawn by the suction boxes, while still more is extracted by a suction or couch roll. At this stage, enough water has been removed from the blanket of pulp so that it can definitely be called a sheet and can be safely transferred from the Fourdrinier wire onto a traveling belt of felt.

By the time the sheet leaves the press-roll section it has lost about half of its original moisture content. The remainder evaporates in the drying rolls, which are steam-heated cylinders 4 or 5 feet in diameter. There are 30 to 40 of these rolls, arranged in two tiers, on each machine. As the paper comes from the last of the drying cylinders, it is wound on a large roll from which it is rewound and at the same time usually cut into smaller widths. A number of additional treatments may be given the paper, depending upon the purpose for which it is intended.

Machine-finished paper receives no surface treatment other than that imparted to it by the Fourdrinier machine and is largely used for books and catalogues. Supercalendered paper, however,

which is required for illustrated magazines and catalogues, is given a smoother surface by running it, under high pressure, through a stack of rolls or calenders, some of highly polished steel and some of softer materials. Where illustrations are to be of an exceptionally fine character, it is necessary to use coated stock. This consists of machine-finished paper to which is applied a coating of very fine china clay and casein. At Rumford, this work is done in a separate section of the mill containing a battery of coating machines and driers. A large department of the plant is devoted to preparing the product for shipment. Some of it leaves in rolls, others in the form of flat sheets; but in either case the paper is carefully inspected and counted or weighed before packing.

During the process of turning wood into paper, you may have noted that the materials are in liquid form the greater part of the time. As a matter of fact, as much as 400 tons of water is used in making a ton of paper. One of the principal pieces of equipment in a paper mill is, therefore, the pump. There are nearly 300 pumps of different types and sizes at Oxford's Rumford mill. Some of them handle water, others are built primarily for pumping paper stock, while still others, of special materials, transfer caustic or acid liquids needed in the digesters. Boiler-feed and other pumps in the power plant help to provide steam for the digesters, for the drying rolls of the Fourdrinier machines, and for many other uses throughout the plant.

But pumps are only one of the many kinds of equipment in service. There are thousands of feet of chain conveyors, three 60-foot and eight 40-foot digesters, and twelve paper machines, as well as evaporators, thickeners, and other items too numerous to mention. The equipment is both huge and delicate, some of it being exposed to severe chemical attack. The Rumford paper mill is, in fact, three plants—a powerhouse, a chemical plant, and a manufacturing plant—rolled into one.

To keep such a mill in operation requires a well-organized maintenance department, and the one in question makes wide use of compressed-air-operated tools. Wherever one goes in the plant one sees such tools applied to spot jobs. Take, for example, a recent repair job in the plant's welding shop involving a stainless-steel suction pipe from the vacuum pump of the acid plant. After the pipe had been welded, it had to be reshaped and finished, and this work was done by five air-operated tools—a scaler, a wire brush, a grinder, a drill, and a blowgun.

A rock drill is always ready for various drilling operations in concrete, even for drilling holes for 4-inch-diameter drain pipe with a 4½-inch bit. Concrete breakers also are available and are often in demand, for there are many foundation and floor changes to be made. The impact wrench finds wide application in taking down and reassembling pumps, pipe flanges, Jordans, and other equipment, while chipping and scaling hammers are used to clean beater rolls, to replace cell linings, and to do numerous other jobs.

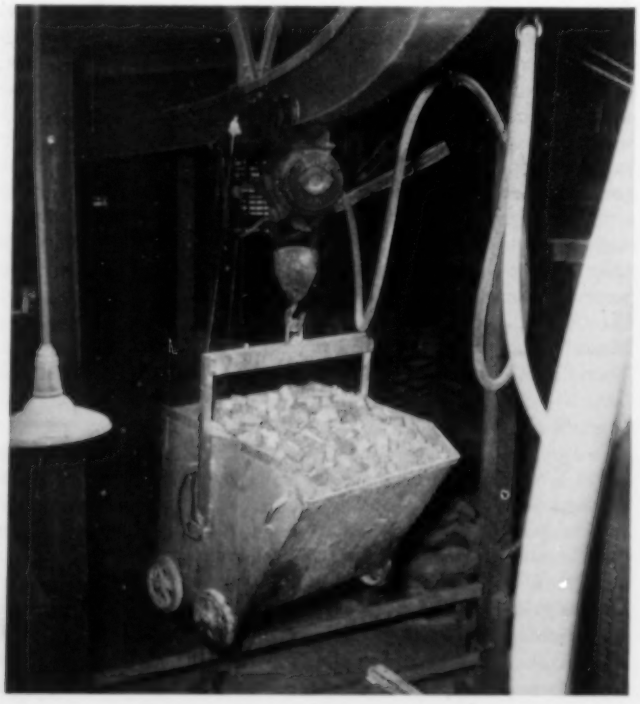
Compressed air is indispensable not only in maintenance work but also in other ways. There is an air hoist to handle ashes from the waste-fuel boiler. A similar unit, with a motor-operated trolley, carries alum from the storage bins to the alum-mixing tank. And air-operated hoists installed at the dry ends of most of the paper machines shift the rolled sheets to the rewinding reels. A pneumatic clamp in the finishing room helps to glue caps on rolls wrapped for shipment. This makes a tighter and neater-appearing package than does hand-capping. Compressed air is also used for agitation and for liquid transfer in the chlorine plant.

The compressor plant consists of seven Ingersoll-Rand units of various types. There are four small air-cooled machines, one of them at the Island Division, that furnish air for particular jobs. The main air supply is provided by one single-stage and two 2-stage compressors. The single-stage and one of the 2-stage units are driven by electric motors; the other 2-stage machine is operated by the use of a water wheel. These compressors were installed over a period of years as the mills' need for air increased.

It is worth noting that the Oxford Paper Company uses four different kinds of power to run the Rumford mill. Air power serves many purposes, as has just been mentioned. Motors, on everything from fans to cranes, are driven by electric power, which is also employed directly for electrolysis in the bleach plant. Steam operates the paper machines, provides heat for the digesters, driers, etc. And waterpower—the forerunner of them all—drives a number of machines in addition to the 2-stage compressor, and is the source of substantially all the electricity used throughout the plant.

MORE USES OF AIR

Alum, one of the papermaking materials, is handled by an Ingersoll-Rand air hoist that runs on an overhead trolley (right). Note how the air hose is arranged to follow the hoist as it travels. The other picture shows a Jackhamer rock drill being used to drill a hole in a concrete floor for a 4-inch drain pipe. A 4½-inch Jackbit is attached to the end of the drill rod.



Anti-Blackout Flying Suits

IF YOU swing a bucket of water in a circle, centrifugal force keeps the liquid from spilling. In a similar manner, when the pilot of a fighter plane makes a pull-up or abrupt turn at high speed, centrifugal force causes the blood to flow to the lower parts of his body and holds it there. This pull against gravity is known in air-force medical circles as the "G" effect. At "5G," or five times the normal pull of gravity, many aviators "black out"—that is, they lose their vision because the heart is unable to pump oxygen-carrying blood to the brain. At "7G," a 150-pound pilot weighs more than half a ton, and his 4-ton fighter plane is heavier than some bombers. His blood grows as heavy as iron and "pools" in his feet and legs. Sometimes he loses consciousness, as well as power to see.

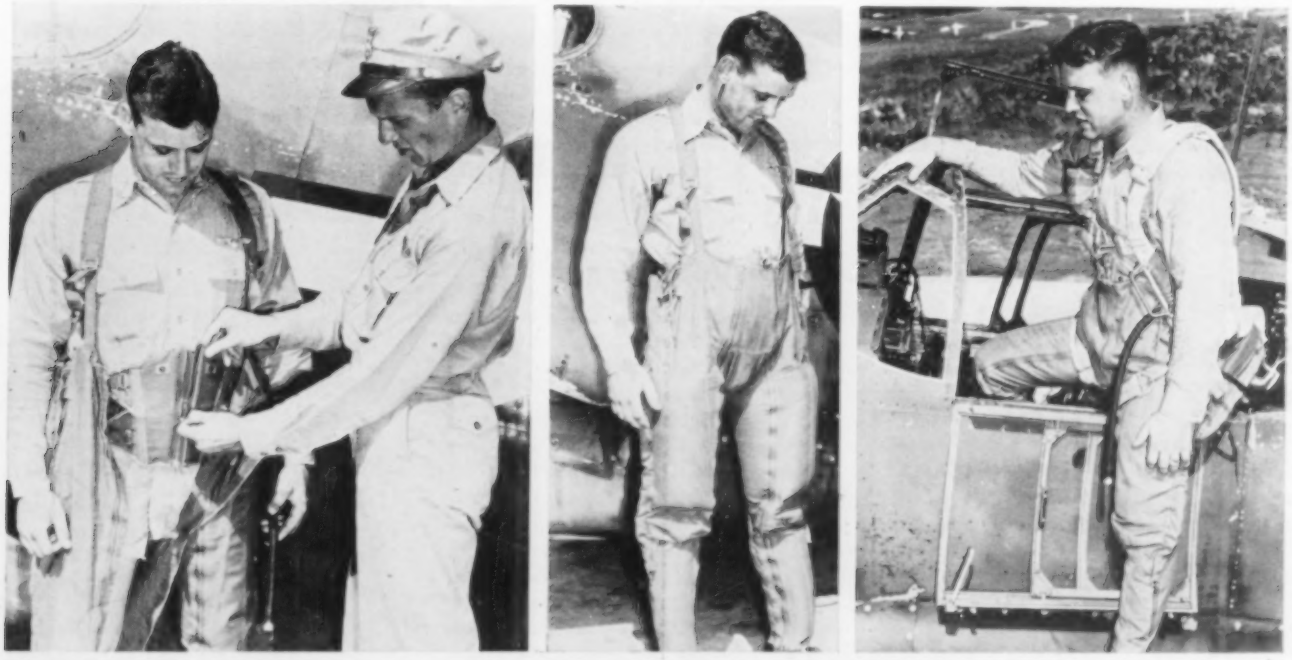
To offset this phenomenon, pilots of our P-51 and P-47 fighter planes now wear pneumatic pants, known as a G-suit. This equipment applies counteracting pressure to the legs and lower abdomen during rapid turns, and sufficiently offsets the G-effect to prevent the dimming of vision. A flier thus protected has an obvious advantage over enemy pilots who are not similarly equipped, and he can out-maneuver them readily. The G-suit has been used with success by aviators of the Eighth and Ninth air forces in Europe, and news of it was withheld until it was known that the Germans were aware of its details.

As accompanying pictures show, the G-suit resembles tight, high-waisted pants, with built-in suspenders and girdle. It has air bladders over the abdomen, thighs, and calves, and these are distended by means of the aircraft's pump that supplies compressed air for instrument operation. The pilot puts the suit on just before going aloft and can wear it partly open until he has need of it. Then he closes it by zippers, plugs the air line into a connection, and an automatic valve does the rest. The latter inflates the bladders when the force of gravity rises above 2G and deflates them when it drops below that figure, either function requiring about two seconds. Although the G-suit theoretically gives the flier an extra tolerance of only 1.9G, fighter pilots report that it actually makes blacking out impossible. They also find that there is a great reduction in fatigue which commonly follows combat maneuvers.

Since the days of World War I, blacking out has limited the maneuvers of pursuit-plane pilots and, as stronger and faster aircraft were developed, the limitation became more evident. The planes could take the quick changes in direction without cracking up, but the airmen couldn't. They learned that crouching and shouting tensed their muscles and increased their resistance to G-effect by restricting the downward flow of blood. However, these actions prevented the flier from looking through the windshield, keeping watch for the enemy above and behind and sighting the guns during a quick turn or pull-out.

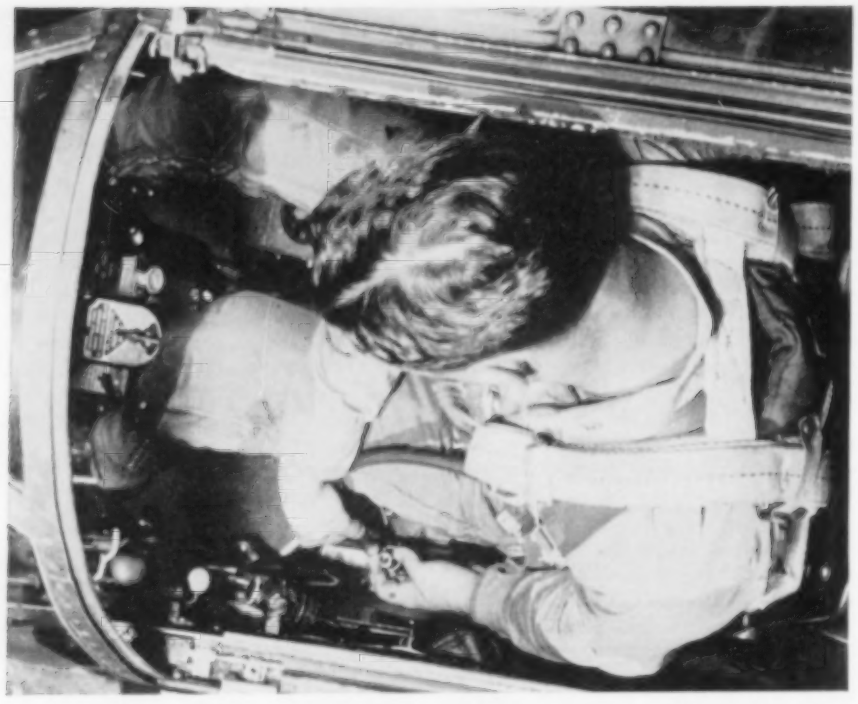
When the present war started, both the Allies and Axis air forces began studying the causes of blackout with a view to devising means of preventing it. The Germans approached the problem from the viewpoint of plane design, and at one period even tried having the aviator fly in a prone position. The Japanese apparently realized that blood must be kept from piling up in the lower extremities and wrapped their fighter pilots' legs tightly with inelastic bandages. Although this accomplished the desired result, it made the men acutely uncomfortable and restricted their movements.

The Allies took the straight physiological approach, seeking to make the airman capable of withstanding the top performance of the plane. The earliest practical suits were developed by the Canadian and Australian air forces. The pioneer work in Canada was done by Dr. William R. Francks, formerly of the University of Toronto, and the suit that he invented in 1939 in conjunction with the Banting Institute of that school and the RCAF was designed to use either water or air as a fluid to build up external pressure to balance the internal



THE G-SUIT

A pilot is being "zipped" into his protective garment at the left. In his left hand he is holding the air hose used for inflating the various bladders. The suit as it appears when inflated is shown in the center. At the right, the pilot accoutred in his G-suit is making ready to go aloft. Note that a parachute is worn over it in the usual manner.



PLUGGING IN THE AIR LINE

The fighter pilot has to make only one simple connection to inflate the bladders of the suit. Thereafter, an automatic valve admits or lets out compressed air as the "G" force varies. If need be, the pilot can use lung power to distend the suit sufficiently to afford the necessary protection.

forces set up by increased gravity. Doctor Francks and some of his associates at the Banting Institute served as guinea pigs for the initial tryouts in a giant "whirligig" that simulated the conditions that would be met in an aerial dog fight. The first test in actual warfare came in 1942, when carrier-based fighter planes of the British Fleet Air Arm speedily swept aside enemy opposition at Oran in French North Africa.

Since 1939 the suit has been modified more than 250 times. As now manufactured, it comes in seven standard sizes which, by means of lacings and special zippers, fit every size and build of body. Doctor Francks is now a wing commander in the RCAF and has been decorated for his part in the invention of the suit. Sir Frederick Banting, his former colleague at the University of Toronto, was carrying data about the suit's construction and performance to England when he was killed in an airplane crash in Newfoundland in 1941.

The U. S. Navy closely followed the Canadians in its development work on G-suits. The Navy's design was modified by the American Air Forces after extensive centrifugal tests at the Aero Medical Laboratory at Wright Field, and within a relatively short time evolved the suit that is now standard for the AAF.

Machine Makes Endless Plastic Tubing

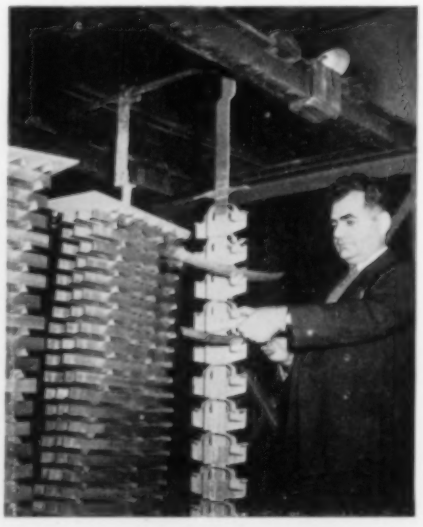
A CONTINUOUS injection molding and extrusion machine for plastics and rubber has been developed by engineers and technicians of the Chrysler Corporation and is said to be a big improvement over the equipment now used for this work. It is reported that the method has great possibilities, especially in the manufacture of seamless tubing of thermosetting plastics. Tubing for overhead or underground service and liners for steel or iron piping can be made of any desired length—from the Atlantic to the Pacific, if handling permitted. And where existing machines turn out an article weighing a maximum of 2¼ pounds, the new one molds an 8-pound battery case. Rubber insulators have been manufactured at the rate of 144 in less than three minutes. These are some of the claims made for the new process by the corporation.

The machine consists of a hopper from which the material passes into a heating cylinder, where it is converted into a puttylike mass by a special churning apparatus. Then it is subjected to a pressure up to 22,000 pounds per square inch by a worm screw, which also forces it between the dies. When the mold is completely filled, the resultant back pressure automatically shuts off the feeder and the screw reverses itself, thus returning the material to the heating tank where it stays pliable, ready for the next injection.

New Anodizing Rack

DIFFICULTIES encountered in anodizing aluminum parts for airplane frames in the plant of the Murray Corporation of America have resulted in the development of a rack that not only multiplies production, it is claimed, but also improves the quality of the work. By the conventional procedure, a single rack could accommodate not more than 26 pieces, each of which was placed on an individual contact on the holding fixture. Those contacts were troublesome: they became anodized and loose, thus retarding the flow of current through the work and causing arcing and burning.

By the improved method of racking, these difficulties are avoided. Contacts are made only at the top and bottom by plates between which the work is stacked in parallel rows and with succeeding layers at right angles to one another. The entire assembly is clamped together tight by a nut and threaded rod, which is attached to the middle of the bottom plate and extends through the top plate and a hanger. Flat material that cannot be placed on edge is alternated with angular pieces in order that there may be a minimum of contact and to allow the electrolyte to reach the surfaces. By this arrangement, a rack can be made to hold as many as 500 pieces, depending upon the type and size, and continuance of the current through the work is assured the entire 30-minute cycle.



OLD AND NEW TYPES

By hooking up parts in series instead of in parallel, each of the anodizing racks at the left can do nearly twenty times as much work as the older holding fixture shown at the center. Their capacity varies with the work, but can be increased by superimposing a plate of larger size on the bottom plate of the assembly. Contact is made only at the top and bottom of the pile. By the conventional method, each part had to be placed on an individual contact, as illustrated by James A. Krimiam, chemical engineer of the Murray Corporation and inventor of the new rack.

TUFF

EDITOR'S NOTE: On page 153 of our June, 1944, issue, mention was made of "tufa, a rock of volcanic origin," which is being used extensively for bridge construction in Nicaragua. Due editorial inquiry was made as to whether we should change *tufa* to *tuff*, as we knew that geologists make a distinction between the two. We found that the authoritative U. S. Bureau of Mines publication, *A Glossary of the Mining and Mineral Industry* by Albert H. Fay, clearly sets forth the difference in meaning between these words and that *tuff* was indicated in this case. We then consulted *Webster's New International Dictionary* and discovered that it lists *tufa* as an alternate for *tuff*. Accordingly, we allowed the word to stand as the author had written it, but with a quaking feeling that somebody with a high regard for being technically correct would catch up with us.

Our fears were justified, for before the month was over we had a letter from Jeffrey Schweitzer of the South Jackson Mining Company in California politely informing us of our error, but not blaming us "because it seems to be all too common." Mr. Schweitzer went on to state, though, that every time he sees this indiscriminate use of *tuff* and *tufa* it does something to him, and added, "I have to get that something out of my system; maybe you know the feeling!" After referring us to Fay's work (which is ordinarily our "bible" in such matters and henceforth will always be our arbiter), he concluded: "Now I feel better, and I hope you do, too."

Mr. Schweitzer didn't feel so much better as to forget the incident, however, for four months later we received from him the following article and illustrations. It takes us over all the *tuff* and *tufa* lexicologic hurdles and presents information about the use of *tuff* as a building stone in the West. We wish all our editorial indiscretions might end as interestingly as this one.

MANY present-day writers, when referring to and describing the rock *tuff*, call it *tufa*. This is not good usage, and is confusing. Originally, it seems, the dividing line was hazy, and *tufa* included those rocks now classified both as *tufa* and *tuff*. Through a period of years the idea of a separation has grown, and to the modern geologist *tuff* and *tufa* have become known as two distinctly different rocks.

Illustrating the growth of the separation, we find in the 1903 edition of Prof. Joseph Le Conte's *Elements of Geology*: "Volcanic ashes, when consolidated by time and percolating water, or when deposited in water, form *tufa*." Today such a rock is called *tuff*.

In the *Geology* of Chamberlain and Salisbury (1904) a differentiation between *tuff* and *tufa* is advocated. Their definition is: "*Tuff (tufa)*—a term including certain porous granular or cellular rocks of diverse origins; the volcanic *tuffs* embrace the finer kinds of pyroclastic detritus, as ashes, cinders, etc.; the calcareous *tufa* embrace the granular and cellular deposits of springs; the better usage limits the term to volcanic clastics."

In Prof. J. F. Kemp's *Handbook of Rocks* (1906) *tufa* is "the cellular deposits of mineral springs, usually calcareous or siliceous. Not to be confused with *tuff*." And, "*Tuff*, the finer fragmental ejectments from explosive eruptions of volcanoes. They may afterwards be water-sorted or cemented to firm rock. Coarser ones are called volcanic breccias, but in neither do we see much sorting unless produced by subsequent erosion. *Tufa* is also used in this sense, but the custom should be discouraged."

TUFF AND ITS SOURCE

The tuff steps of the Amador County Court House at Jackson, Calif. (below, left), proved more durable than the concrete steps of the adjoining Hall of Records. The tallest of the structures at the right is the I.O.O.F. Building at Mokelumne Hill, Calif. It was constructed in the 1850's and is faced with tuff. It is reputed to have been the highest building in the West when it was erected. At the lower right is Butte Mountain, a solid mass of tuff, with Moore Mine in the foreground.

This recommendation finally took form, and by 1920 *tuff* and *tufa* meant two distinct classes of rock. Quoting from A. H. Fay's *A Glossary of the Mining and Mineral Industry*, U. S. Bureau of Mines Bulletin No. 95, *tufa* is "A chemical sedimentary rock composed of calcium carbonate or of silica, deposited from solution in the water of a spring or of a lake or from percolating ground water; sinter. Should not be confused with *tuff, which see.*" The latter is "A sedimentary rock composed of fine material—volcanic dust, so-called ash and cinders, and lapilli—explosively ejected from a volcano. *Tuff* may or may not be deposited in water; it may be either heterogeneous or rather well sorted, and it may be either incoherent or indurated."

Tuff is a common rock in the West. When freshly mined it is soft and can be cut easily by an ordinary wood handsaw, but after exposure the rock hardens. This characteristic has resulted in the formation of certain individual mountains, for as the surrounding rocks were eroded away, the hardened noneroding tuff remained. As a typical example of such a mountainous mass is Butte Mountain (Jackson Butte on the United States geological maps), a prominent peak 3 miles southeast of Jackson, Amador County, Calif. The whole top of it is tuff, at least twenty million tons of it, overlaying a deposit of gravel that, in spots, was mined for gold.

The average piece of this tuff is fine-grained with some large irregular inclusions. Its color is pink, and from a distance the mountain has a pinkish tinge even though covered by a thick growth of brush. The rock contains considerable mica which gives a golden reflection in sunlight. With the pink coloration as a background, this golden effect is striking.

The material has been used locally to a limited extent for building purposes. Several houses in Jackson constructed of the Butte Mountain tuff in the early days are in excellent condition and present an attractive appearance. The tuff steps of the old Amador County Court House, at Jackson, laid down about 1870 and in continual use until removed in the middle 1930's when the structure was rebuilt, showed no signs of wear, while the concrete steps of the adjoining Hall of Records, constructed years later, were badly cupped.

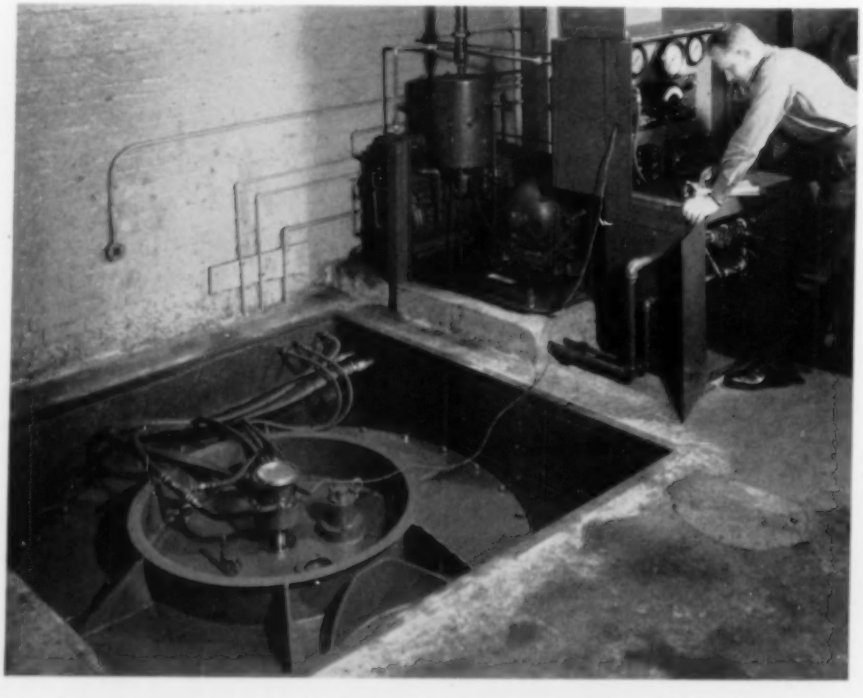
The fresh tuff, being soft and easily crushed, may be mixed with concrete to color the latter and to add strength against abrasion. Because of the nature of the rock, air-driven tools might be employed to advantage both for economy and speed in quarrying and dressing operations. One would think that tuff, so widely scattered and so easily worked and in many cases an attractive rock, would be used much more extensively.

Vacuum Test Pit for High-Speed Fans

IN THE research laboratory of the Buffalo Forge Company is a large vacuum test pit which is a good example of what is being done to improve high-speed rotary machinery by studying the stresses to which they are subjected in service. It is designed to determine the efficiency of impellers or fans and is of heavy reinforced-concrete construction which enables it to withstand absolute vacuum. Because of this, it takes very little power to spin a fan, sometimes to destruction.

The impeller to be tested is hung by a slender shaft from a small air turbine mounted on the cover of the pit or shell, from which the air is then exhausted by a vacuum pump. Evacuation may be carried to a point as low as 200 microns, or 0.00787 inch of mercury, absolute, as compared with standard atmospheric pressure of 29.92 inches of mercury. Under such conditions, a fan that would normally require 1000 hp. to drive it can be spun with ¼ hp., exclusive of the power needed to overcome turbine friction. The rate of acceleration must be gradual, and the operator is able by means of an air valve and an air brake to keep the speed under constant control. To prevent the speed indicator from absorbing power at the higher speeds, an electronic frequency meter is used. This is a direct-reading, dial-type instrument with suitable amplification.

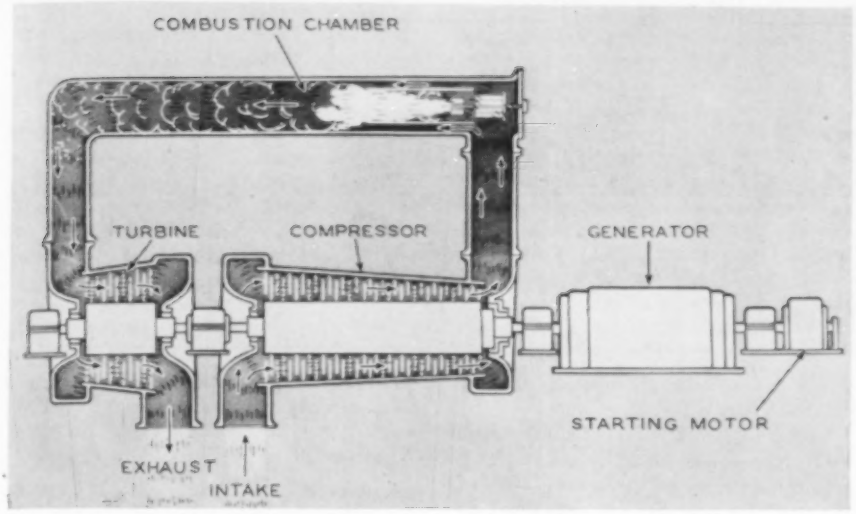
The pit is built along the same lines as that in which the General Electric Company is testing airplane turbo-superchargers that are capable of running at 60,000 rpm., but it is being used to study the behavior of larger impellers at lower speeds. It is 6 feet in diameter and 4 feet deep and makes it possible to drive cast or fabricated fans at sufficient overspeed to permit calculating their factor of safety. In the case of a new design, an impeller may be tested to destruction to determine its weakest point or some otherwise unpredictable condition. For that reason, the main shell in which the vacuum must be maintained is provided with a laminated shield against which the force exerted by the ruptured fan may spend itself. Further, it permits checking the balance of high-speed units, something that is generally not feasible except at the time of installation, and also offers an opportunity to study stresses while an impeller is in operation. For this purpose there is a glass window in the cover of the pit through which the fan can be viewed by stroboscopic light, while the use of strain gauges in circuit with a cathode-ray oscilloscope enables the test engineer further to visualize stresses and vibration.

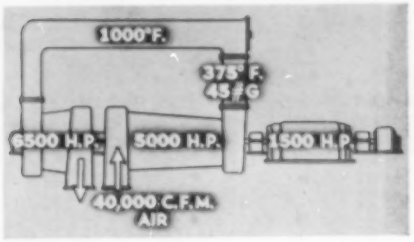


HIGH VACUUM—LITTLE HORSEPOWER

Corner in the research laboratory of the Buffalo Forge Company showing the sunken test chamber with the cover in place. The operating equipment and control panel are at the right. The pit is 6 feet in diameter and 4 feet deep and is built to withstand absolute vacuum. Under that condition, a fan can be driven at one four thousandth of the horsepower that it would require under standard atmospheric pressure. The fan is operated by an air motor.

The Gas Turbine





OPERATING DIAGRAMS

The drawing at the left illustrates how a simple gas turbine functions. A starting motor is required to put the cycle into operation. After passing through the turbine, the gas is discharged to atmosphere. The diagram above gives general operating data. In a unit of this size there is a surplus of 1500 hp. that can be used to run the generator. The illustrations on this page are from a motion picture, "Tornado in a Box," that has been released by the Allis-Chalmers Manufacturing Company.

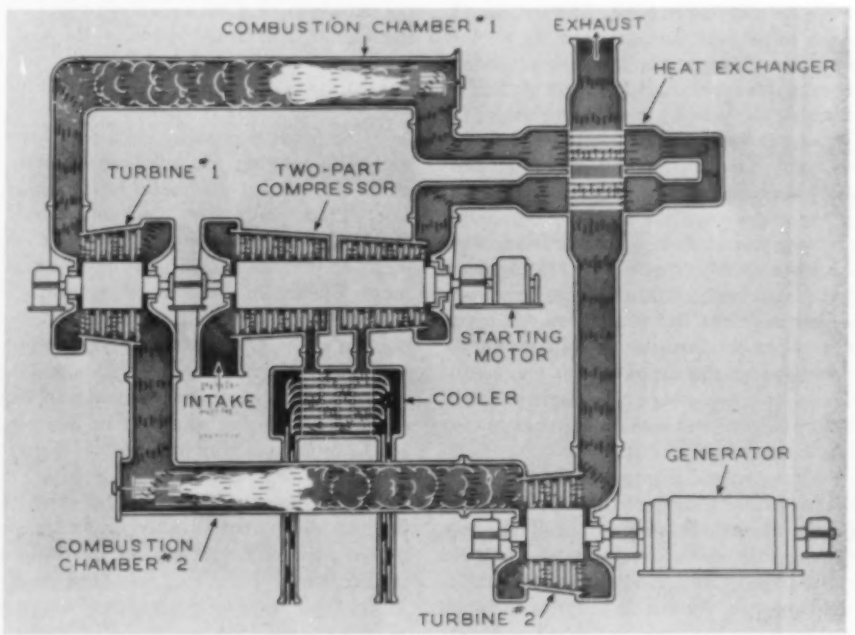
THE gas turbine, about which much is written these days, depends upon the expanding force of compressed air for its operation. The idea is not new, such a machine having been visualized by Leonardo da Vinci five centuries ago. A patent covering the basic elements of the cycle now employed was issued to John Barber in England in 1791.

Air can be put under pressure either by compressing it or heating it, and both methods are brought to bear in the gas turbine. The initial pressure is obtained by passing the air through a compressor. The work done on it appears in it as heat, the temperature varying with the pressure. Thus, if atmospheric air is compressed to 45 pounds per square inch, which is about the pressure being used, it will have a discharge temperature of around 375°F. This air is then led to a combustion chamber, where a small proportion of it combines with fuel and is burned. The rest passes through the annular space around the burner and joins the combustion gases, which raise the temperature of the mixture to around 1000°F. and coincidentally increase its volume. The air-gas mixture is next led to a turbine, and its expansion while passing through the blades rotates the latter just as steam does in the conventional turbine. Some of the power developed in the turbine operates the compressor; but there is a surplus, and this can be utilized to perform useful work such as driving a generator.

The foregoing is a sketchy outline of the gas turbine in its simplest form. In the cycle traced will be produced a thermal efficiency of around 20 percent, as compared with 32 percent for a steam turbine of latest design. After passing through the turbine, the air-gas mixture is discharged to atmosphere and some pressure and heat are wasted with it. By making provision to reuse this mixture and by introducing some additional features in the cycle, machines have been developed that have a thermal efficiency of around 30 percent.

The gas-turbine cycle is the simplest power-producing cycle known. It eliminates boilers and does not involve the use of reciprocating parts. Consequently, it is easy to see why it has engaged the attention of engineers and scientists for a long time. There have been two principal obstacles blocking its development, and these have been overcome to some degree by recent research. One of these requisites is an efficient compressor, and the other is metals that will, over long periods, withstand the high temperatures necessary to obtain the thermal efficiency required to make such a machine competitive with the highly developed steam cycle.

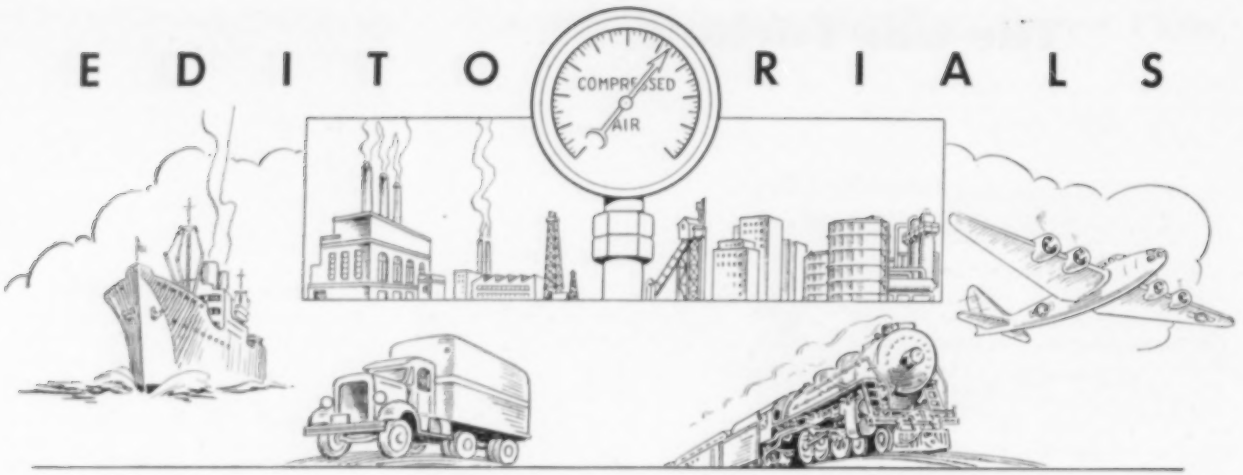
Thus far three practical applications of gas turbines have been made. In two of them, the airplane-engine supercharger and jet-propelled planes, the service life is relatively short, being on the order of 1000 hours. The third is in connection with the Houdry process of manufacturing high-octane gasoline, and there some units have been in service two years.



CLOSED-SYSTEM TURBINE

Instead of discharging the exhaust from the turbine to atmosphere, it is run through a second combustion chamber and then made to operate a second turbine of lower horsepower than the first one. To get better efficiency from the compressor, it is designed in two stages with an interposed cooler.

EDITORIALS



CALL FOR PROSPECTORS

THE Dominion of Canada, which counts mining as one of its principal industries, is starting a movement to stimulate prospecting. Prominent mining men, including Robert C. Stanley who is head of the International Nickel Company of Canada, Limited, are helping, both with their counsel and their finances, to launch a plan that will make prospecting more of a systematic, well-ordered business than it has been in the past. The immediate instrument for putting the scheme into operation is the Prospectors and Developers Association, whose chief objective is to carry out an educational program designed to interest returned service men in the search for new mineral fields and then to give them the fundamental knowledge necessary to carry on their work intelligently. It is a long-range plan, aimed at maintaining Canada's position as one of the foremost metal-producing nations. It is proposed, first, to make a complete survey to find out how many men should be placed in the field and, next, to train a sufficient number of them to meet the needs.

In the past, men have sought new mineral deposits almost solely because they wanted to. Few of the old school of prospectors ever had any backing, other than an occasional grubstake from some kindly soul who was motivated as much by charitable inclinations as by any hope of getting rich. Mr. Stanley and some of the other proponents of the new movement are of the opinion that the established mining companies ought to help finance prospecting as insurance for their own welfare.

Manpower shortages during the war have seriously depleted the ranks of the prospectors. Even in normal times a large proportion of those in the field were elderly men, and many of them relied upon a "nose for ore" rather than upon technical training. Considering their shortcomings, they did very well, but had they been better equipped with knowledge and finances they probably would have done much better. At least, numerous ore bodies now in production would have been discovered and developed years before they were.

There is also a psychological reason why prospecting should be made a business rather than an adventure. This is the need for opening up additional deposits of base metals. During the war, North America has been spending its resources in iron, copper, lead, zinc, and kindred metals at an alarming rate. Vast quantities of them have gone to the fighting fronts in the form of war matériel and will never return. On the other side of the ledger is the fact that few new finds of base metals are being made. Mr. Stanley points out that there has been no major Canadian discovery in this category since Noranda was opened up in 1922.

There is a logical reason for this. The lure of gold has always been the prospector's strongest urge. If he stumbled upon any base-metal deposits, he reported them, but he never went out of his way to search for them. The prospector has never been a developer. He has traditionally made his find, sold it for whatever he could get, and passed on to look for other deposits. Because of the universal longing for gold, any worthwhile showing of the metal has a ready sale. That is not true, however, of base metals. They must be proved to exist in large quantities before anyone will risk much money in their development.

Mr. Stanley proposes an entirely new deal for the prospector. He suggests that he should be guaranteed a substantial interest in his discoveries instead of being obliged to take whatever he can get. He recommends that moderately priced transportation be furnished him in Forestry Branch airplanes and that he be provided with suitably drawn maps and a continuing supply of up-to-date information. He also urges that he be given legal protection against unscrupulous promoters who have often mulcted him. Finally, he stresses the importance of keeping alive the fire of hope, the promise of possible big rewards that has always kept the old-time prospector probing for hidden wealth. There must be an element of gambling in the game to keep men at it. "If everyone had always played 100 percent safe," he says, "there would be few large mines today."

CENTRAL TOOL CONTROL

A CENTRAL tool shop that controls and repairs all loose portable hand and power tools used in one division of the Puget Sound Navy Yard at Bremerton, Wash., has been found to be an aid to ship production. This depot is responsible for the storage, issue, upkeep, and salvage of the tools, and it even makes some of the accessory equipment.

Under this system, tools are always kept in good repair. Consequently, they give more service over a stated period and last longer than when the craftsmen handling them are held responsible for them. As an instance of how the centralized control plan works to advantage, W. E. Ainsworth, master mechanic at the yard, points to flat chisels used in pneumatic chipping hammers.

This type of chisel is the most used tool in the yard, and any improvement in the method of handling it therefore has a large over-all effect. The chisels are reconditioned by the thousands each day, and it was found that the operators who formerly reground them freehand were not achieving uniform results, regardless of their individual skill. To overcome this shortcoming, the central shop bought an automatic chisel grinder, a new type of machine not previously utilized elsewhere. It has now been in service for several months with such success that consideration is being given to discontinuing all hand grinding.

Other advantages of centralized control will be immediately apparent to foremen of shops requiring large numbers of small tools. Anything that gets more work out of a tool saves manpower, not only in the shop where it is used but also in the factories that supply new tools, in the steel mills and other establishments that furnish material, and even in the mines that produce the metals that go into them.

This and That

Bats Use Radar

The science of radar is new to man, but bats have used it since time immemorial, according to Dr. Robert Galombos, Harvard University researcher. These nocturnal wanderers emit cries so shrill that the human ear does not hear them. The sounds are echoed back to the bat by any obstacle in the way, enabling it to change its course to avoid collision. By gagging bats and then freeing them, Doctor Galombos was able to prove that they are helpless without the guiding echoes.

★ ★ ★

Oil Sailers of Old

An article in this issue about the birth of the modern tankship may leave the impression that the carrying of petroleum and its products in containers aboard ship was virtually discontinued within a short time after a satisfactory way of transporting them in bulk had been devised. This was not the case, for while tankers did come into service in large and increasing numbers, the fleet of vessels handling packaged oil grew simultaneously. This anomalous situation arose because of the mounting demand throughout the world for petroleum derivatives, especially for kerosene.

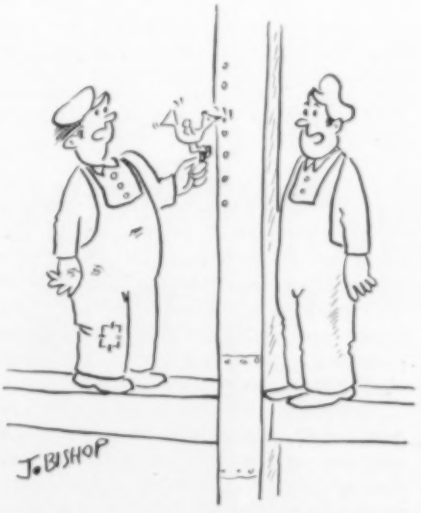
In the late nineties, Australia and New Zealand used more than a million cases of oil annually, and the needs of India, China, Japan, and the East Indies were even greater than that. The nature of the cargo was such that rapid delivery was not of great importance, so most of the trade fell to sailing vessels which, although slow, were comparatively inexpensive to operate. Thus it happened that at the very time when steam was threatening to replace sails, the windjammers were given a new lease on life by this worldwide demand for oil. This trend is discussed in an interesting book, *Coolie Ships and Oil Sailers*, which was written some years ago by an Englishman, Basil Lubbock.

It was this oil trade that produced the giant sailing ships of that day. They were of 3000 or more tons carrying capacity, and some of them became famous in maritime circles. The *Palgrave*, an iron-hulled 4-master of 3187 tons, was known as the modern Noah's Ark because she was built on the same proportions as the biblical craft. The Ark was 450 feet long, 75 feet wide, and 45 feet deep, the ratio of these measurements being 30 to 5 to 3. The *Palgrave* was the largest sailing vessel in the world at the time of her launching. She suffered a series of mishaps that gave her the reputation of being a "crank," meaning that she was difficult to handle. She was dismasted twice in storms, and it was as a result of the second of these occurrences that what is now known as the valuation clause came to be included in all ship insurance policies. This clause specifies that for constructive total-loss purposes the insured value shall be taken as the value of the vessel when repaired.

The *Palgrave* had many captains, and at least one of them, G. M. Dixon, warmly defended the ship and claimed she was not "cranky." On one occasion he got 300 knots out of her in 24 hours, and he reported that while he was her master she gave no trouble and required no major repairs. The *Palgrave* was nearly lost in 1906 when she was blown ashore at Alcatraz Island in San Francisco Bay, and two years later she broke to pieces after having gone aground on the coast of Chile while laden with a cargo of coal.

Around 1900 the Anglo-American Oil Company bought twelve sailing vessels for the oil trade and built eight more in England. Six of the latter were of more than 3000 tons each. The Standard Oil Company also constructed three big oil sailers. Among the more famous of them was the *Quevilly*, a 4-masted bark of 3482 tons. She was designed to carry petroleum in bulk. Built at Rouen, France, in 1897, she was among the first ships to have electric lights and some other modern conveniences. She carried a million gallons of cargo on her run between Rhiba and Rouen and was reported to handle "like a dray," but seems to have kept out of trouble. On one trip she made better time than a steamer, despite the fact that one day's run was only 70 miles. As was the case with all big sailing vessels, she could make good speed under favorable conditions, meaning fair, strong winds.

In 1911 the *Quevilly* was fitted with two diesel engines of a type then being used in submarines. These drove her at a speed of 5 or 6 knots when there was no wind, but the drag of the twin propellers spoiled her sailing performance. In 1917, she was stationed in the Azores, where she served as an oil-storage ship for bunkering Allied craft during the war. She returned to her old run in 1919, but could not compete with modern tankers and was laid up at Rouen in 1921. Norwegian interests bought her in 1923 for use as a whale-oil carrier or floating depot. She was renamed the *Deobata*, and as recently as 1935 was known to be still earning her keep. Other famous sailing oilers that spent many years in service were the *Daylight* and the *Eclipse*.



"I'm going to try to make this woodpecker work until I get a new air hammer."

★ ★ ★

Russians Pretreat Sugar Beets

By extracting the juice from sugar beets and then concentrating it through evaporation it is possible to form solid briquettes that can be used later to produce sugar. This simple method of initially treating the beets has been worked out in the Russian Ukraine, according to a report in *Foreign Commerce Weekly*. The concentration process extracts the water, which amounts to 75 percent of the beet content. Cost of transportation is consequently greatly reduced, for in Russia the beet-processing factories are usually located far from the growing fields. This is not ordinarily the case in the United States; but the new procedure might, if adopted here, give rise to other savings.

Beets are harvested in the autumn and are processed as quickly as possible to avoid spoilage, complications resulting from freezing, etc. The sugar-making campaign generally lasts only two or three months at the most, and the costly factories are idle the remainder of the year. As the briquettes can reportedly be stored without loss or deterioration, adoption of the process might enable the refineries to run the year round, thus reducing the number required to serve a given beet-growing area. In Russia, the juice is extracted and concentrated in inexpensive plants of a size sufficient to handle the output of one large or several small collective farms. Their daily capacities range from as little as 25 to 100 tons of beets, and they need only from 30 to 75 hp. for their operation.

New Publications

AIR COMPRESSORS

A TIMELY book on air compressors has been written by Eugene W. Feller, associate editor of *Power* magazine. It is timely because, as the author states, "industry is becoming more air-minded every day and it is only natural that users want to know the most economical means of supplying compressed air." It is timely also because there is no other recent book on this subject, and it contains much up-to-date information that could hitherto be obtained only by searching through the files of various magazines.

Mr. Feller's book is a practical work that shuns theory and gives the operating engineer facts that will assist him most in determining the type of equipment that will best meet any given set of conditions. It contains down-to-earth descriptions of all classes of compressors, including the axial-flow type used in gas turbines, and has curves and diagrams showing the working principle of each. Installation, operation, and maintenance are all given attention.

The author is qualified to write from the operating engineer's viewpoint because he was formerly chief operator of the Safe Harbor Water Power Corporation. Although the book was intended primarily for those who are already in industry, it should also appeal to engineering students.

AIR COMPRESSORS, By Eugene W. Feller, 460 pages. McGraw-Hill Book Company, 330 West 42nd St., New York 18, N. Y. Obtainable also from Compressed Air Magazine Company, Phillipsburg, N. J. Price, $4.50.

GLOBAL WARTIME CONSTRUCTION

THE reporting of this war is in keeping with the magnitude of the action. Press and radio representatives actually go into battle and send back vivid impressions that are as complete as censorship will permit. As this is "an engineer's war," with construction projects dwarfing those of previous conflicts, it is appropriate that technical journals as well as general publications should send newsmen to the battle zones. This is what *Engineering News-Record* has done and is still doing. Five men on its editorial staff, bearing the credentials of war correspondents, collectively traveled 100,000 miles in 1943 and 1944 to report upon the engineering and construction side of the war.

Much of the material these men gathered appears in the pages of the publication they work for. Much more information, plus the observations of the reporters, went into notebooks that were carried back home. From these sources the five writers have put together 36 short articles that have been issued in book form. Although they contain technical information, these accounts are of the human-interest type designed to entertain as well as inform the reader. As such, they should appeal to everyone. The book is capably edited and well illustrated.

BULLDOZERS COME FIRST, By Waldo G. Bowman, Edward J. Cleary, Harold W. Richardson, Nathan A. Bowers, Archie N. Carter, 278 pages. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price, $2.75.

NEW AUDEL VOLUME

ANOTHER practical engineering book is *Audels Pumps, Hydraulics, Air Compressors*, by Frank Graham. This is really three books in one, as it consists of separate sections devoted to the three subjects in the title. Among its numerous illustrations are elementary sketches or diagrams that are designed to explain basic principles, while the various types of machines discussed are shown as reproductions of photographs. In compiling his information, the author consulted leading manufacturers of the equipment concerned, so that the book presents a cross section of current construction and operating practices.

The book contains considerable fundamental data on hydraulics, physics, and the other sciences that will prove helpful to the man who operates any of the machines described. It also makes effective use of the question-and-answer system to bring out information that will solve most of the problems which confront the operator from day to day. A ready reference index makes it possible to use the book to the best advantage.

AUDELS PUMPS, HYDRAULICS, AIR COMPRESSORS, By Frank Graham, 1658 pages. Theo. Audel & Company, 49 West 23rd Street, New York, N. Y. Also obtainable from Compressed Air Magazine Company, Phillipsburg, N. J. Price, $4.00.

LUBRICATING AIR TOOLS

THE November, 1944, issue of *Lubrication*, published by The Texas Company, is devoted to a discussion of the lubrication of portable air tools. Copies are available free of charge at the company's principal office, 135 East 42nd Street, New York 17, N. Y.

The article deals primarily with the new, small, high-speed air-driven tools that are used in great numbers in producing aircraft and other vital implements of warfare. It tells how they work, shows cross sections of the various types available, and indicates their lubrication requirements.

Choice of the means of lubrication is held to be largely the responsibility of the tool manufacturer. The characteristics of a suitable lubricant are outlined, and the suggestion is made that selection of a particular brand be based on the integrity of the oil refiner, his ability to produce dependable lubricants, and the reputation of his lubricants. It is advocated that the tool user aim at buying lubrication service, not just lubricants, as this will "react in lower maintenance costs and less time out for repairs."

For determining when additional oil is required, the simple expedient of placing a piece of white paper across the tool exhaust is recommended. As long as oil droplets appear on the paper, it is known that oil is passing through the tool. Emphasis is placed on the wisdom of furnishing dry, clean air to the tools through the use of aftercoolers, air-line separators, etc. The article concludes with a table indicating how to detect various troubles and how to remedy them when they are found.

CORROSION PREVENTION

ALL metals except the noble ones are continually being attacked by corrosive agencies. Surface evidences of the resultant deterioration range from rust on iron to tarnish on silver. One may be as detrimental as the other, depending upon the intended use of the product. There are instruments so delicate and surfaces so highly polished that even fingerprints will corrode them. High-precision gauges, for instance, become dimensionally incorrect from even a trace of corrosion. Accordingly, some products must be finished without the hands touching them.

The whole subject of corrosion is treated in a new handbook, *Rust*, published by E. F. Houghton & Company, 303 West Lehigh Ave., Philadelphia 33, Pa., which will supply a copy upon request. Although all phases of corrosion and its prevention are touched upon, the discussion of preventive measures is confined to the field of easily removable or "temporary" protective organic substances, which are generally petroleum products.

The experience of the Houghton Company in these matters goes back to 1869, when it first supplied the Government with the forerunner of its present line of Cosmoline and Rust Veto preventives. Starting with Greeley's 1883 polar trip, Houghton products have been used on other well-known expeditions such as Admiral Byrd's polar explorations and the flights of Lindbergh and Amelia Earhart. The book gives complete data on all the company's corrosion preventives.

Industrial Notes

FOR PROTECTION—NOT STYLE

Neat, snug, and comfortable, this spat has been designed by the American Optical Company to protect the foot and ankle against acids, alkalies, oils, solvents, and greases. It is made of a coated fabric that is said to combine the virtues of rubber with lightness. For adjustability, it is provided with three snap fasteners at the top and two at the bottom.

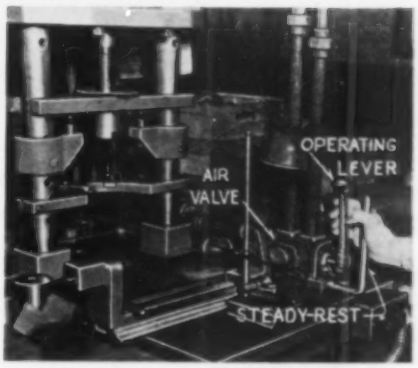
For greasing valves, plug cocks, etc., Dow Corning Corporation has a new lubricant that has the consistency of vaseline and retains it within a temperature range of −40 and +400°F. Further claims made for the compound are that it does not corrode metals, does not affect natural or synthetic rubber and plastics, and is resistant to attack by acids, alkalies, and oxidizing agents. It is obtainable in 8-ounce collapsible tubes, in 10-pound cans, or 85-pound drums.

Sheet aluminum ready for brazing is a new product of the Aluminum Company of America. The basic material is coated on one or both sides with a brazing alloy that melts and flows when the sheet, or parts made from it, are heated in the presence of a flux. The temperature applied must, of course, be above the fusing point of the coating and below that of the aluminum. It is claimed that the bond between the metals is such that the sheet can be bent, drawn, and hammered without damage to the coating. The name of the new material is Aluminum Brazing Sheet. It is available in varying alloys and coatings to meet strength and temperature requirements.

Plywood tubing is a new product that is being offered by the Plymold Corporation under the name of Plytube. It is built up of strips of thin veneer bonded by a thermosetting resin and is now available in varying diameters (inside) and thicknesses ranging, respectively, from ½ inch to 18 inches and from 0.05 to 0.5 inch. So far it is being made in definite lengths, but the manufacturer is constructing an automatic winding machine for continuous production. Plytube is said to be water-, flame-, splinter-, and rotproof, and can be threaded with ordinary pipe dies. It has many industrial and structural applications; and when suitably coated can, it is claimed, be used to carry chemicals, gasoline, and oil.

Award to F. W. Stiefel

Fred W. Stiefel, New York contractor, has been awarded the 1944 Construction Engineering Prize for the best scientific or educational paper on construction published in *Civil Engineering*, official magazine of the American Society of Civil Engineers. His article is in the April issue and deals with the sinking of an inclined shaft at the Fisher Hill Mine of the Republic Steel Corporation near Port Henry, N. Y. In our December, 1941, issue we published an article by Mr. Stiefel describing the work done on one of the Delaware Aqueduct contracts by Samuel R. Rosoff, Ltd., of which Mr. Stiefel was then chief engineer and manager.



Westinghouse Photo

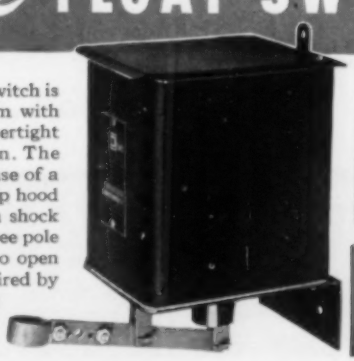
SENSITIVE CONTROL

The commutator press shown here is operated by compressed air and is controlled by a lever through the medium of an air valve. It features a steady-rest or upright arm that is mounted in front of the lever and that enables the pressman to operate the machine simply by closing his hand. He grips both the lever and the steady-rest, as pictured, moving the lever toward the stationary arm with four fingers. As a result of the changeover from the customary free arm movement to a supported squeezing action, it is possible for him at all times effectively to control the air pressure, or the rate at which the press descends.

Graphic symbols for electric and electronic equipment have been unified into a consistent set of signs that will mean the same thing to everyone who uses them. This has been accomplished through the establishment of a new American War Standard just completed by the American Standards Association. The need for such a system of indicating electrical circuits and equipment on engineering drawings has long been recognized. Previously one symbol was sometimes used to indicate two different pieces of apparatus, and in some cases two different symbols meant the same thing. The new standard, although it represents a compromise, is a workable solution of a problem that has been

Marine FLOAT SWITCH

DRIPPROOF AND WATERTIGHT
HIGH SHOCK CONTACT BLOCK
TWO OR THREE POLE
CLASS 9036 • TYPE AW-H



● The class 9036 type AW-H float switch is built for Marine Service to conform with requirements for a dripproof and watertight device of shockproof construction. The switch differs from standard in the use of a special sheet steel enclosure and drip hood with gasket seal and a special high shock bakelite contact block of two or three pole form. The switch can be arranged to open or close on rise in liquid level as required by application. Mounting is three point by means of bracket flange and foot, as illustrated. **Write for Bulletin 563.**

ELECTRICAL RATINGS

Voltage	Single Phase A. C.	Polyphase A. C.	D.C.
110V.	2 H.P.	3 H.P.	1 H.P.
220V.	3 H.P.	5 H.P.	1 H.P.
440-550	5 H.P.	5 H.P.	.....
32V.	.....	.....	½ H.P.

REGULATOR DIVISION
SQUARE D COMPANY
DETROIT • MICHIGAN

irritating to engineers. It was developed through the coöperation of many national groups and members of the armed forces. Copies of Coördination of Electrical Graphical Symbols, Z32.11-1944, may be obtained for ten cents each from the American Standards Association, 29 West 39th Street, New York 18, N. Y.

Through the large-scale production of sulphamic acid, which was for years a laboratory curiosity, we have today the sulphamate-lead-plating process—a low-cost method of providing steel with a protective coating. The latter is serving as a substitute for critical coating materials and will be available for general use after the war. The salts of sulphamic acid have exceptionally high stability and water solubility, qualities that are of importance in lead electroplating.

For the remote control of pneumatic equipment operated at a minimum pressure of 40 pounds, A. Schrader's Son has a new 4-way valve—the No. 2555. It is for use with ½-inch lines and actuated by a pneumatic pilot valve through the medium of a hose connection. Air is thus admitted to the housing of the main valve and moves a crosshead which, in turn, opens and closes poppets. Motive air is introduced through a centrally located port and thus directed to one or other of the four passages.

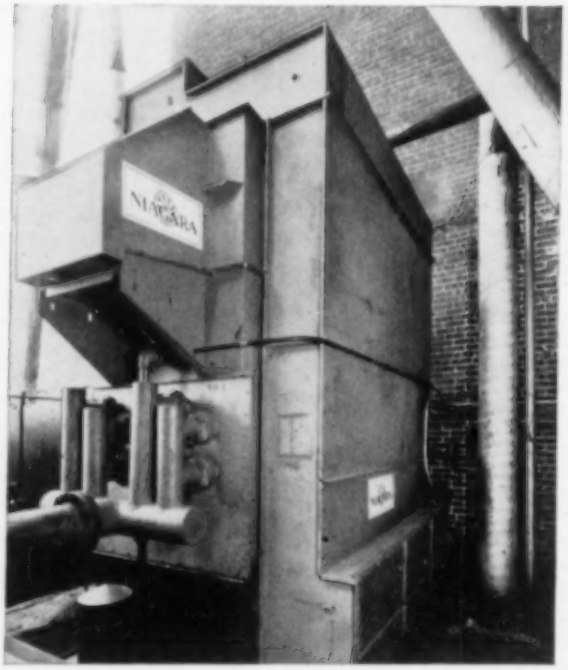
Steel, copper, brass, bronze, zinc, nickel, tin, gold, silver, aluminum, magnesium, and other metals and alloys may be colored by a simple process of chemical immersion, according to a recent announcement of the Technical Processes Division of the Colonial Alloys Company. The concern makes up test specimens from samples sent by the user and, if they meet with approval, prepares coloring salts or solutions to meet individual needs. Iridescent and matte effects in a long range of colors are obtainable; and many of the baths are said to increase the corrosion resistance of the metal as well.

Flexible connectors to absorb expansion, contraction, and deflection in all planes in pipe lines are being produced by Zallea Brothers & Johnson for service in chemical, petroleum, and power plants. They are designed for handling corrosive liquids and gases under pressures up to 30 pounds per square inch at temperatures ranging from subzero to 1800°F. The units are corrugated circumferentially, are 6 inches in diameter and larger, and are made of carbon steel, stainless steel, and other corrosion-resistant alloys. They are said to remain permanently tight without packing. For absorbing linear expansion only, the company can furnish connectors for pressures up to 300 pounds per square inch.

Improved AFTER COOLING METHOD

DRIES COMPRESSED AIR MORE THOROUGHLY

and Saves Cooling Water Costs



U. S. Patent Re-issue No. 22,533

"BALANCED WET BULB" TEMPERATURE CONTROL

EXTRA DRYNESS is vital to industrial users of compressed air, as in spraying protective coatings or in using air to clean fine instrument parts. And you protect all air tools, grinders, hammers, riveters—from water damage, from freezing and from loss of lubrication when the air is thoroughly dried in the NIAGARA Aero AFTER-COOLER.

Obtaining lower temperatures than with ordinary after-cooling, the NIAGARA Aero AFTER-COOLER produces air that is far drier. An *evaporative* cooler, it does not consume water, but repays its cost by eliminating water bills. It also provides controlled temperature for jacket and intercooler water with the Niagara "Balanced Wet Bulb" control which automatically assures the correct admixture of fresh outdoor air with recirculated air.

Write for Bulletin 96 and 98

NIAGARA BLOWER COMPANY

Over 30 Years of Service in Industrial Air Engineering

Dept. CA-25, 6 E. 45th St. NEW YORK 17, N. Y.

Field Engineering Offices in Principal Cities

INDUSTRIAL COOLING HEATING • DRYING

NIAGARA

HUMIDIFYING • AIR ENGINEERING EQUIPMENT

1900-foot rubber band snaps iron through a mountain

A typical example of B. F. Goodrich development in rubber

WAR DEMAND for iron ore last year was so great that companies searched out even the "worked over" mines. The one in the picture had some ore—but at the bottom of a pit.

The way to get it out was by conveyor belt, but that would be the highest single lift of any belt in the world and conventional belts that were strong enough would be too stiff to trough and carry heavy ore up the mountain side. So three belts were used, each for a third the distance, but even they wore out fast and transfer points required much attention.

An engineer at this mine had heard of B. F. Goodrich cord conveyor belt. Made of parallel cords in rubber instead of woven fabric, it is many times as strong and still as flexible as any former belt. Extraordinary records made by this new B. F. Goodrich belt on other "impossible" jobs convinced the engineer it would stand the strain on this one.

The belt was installed, at a 35% grade—almost a rubber elevator. The shaft went through the mountain itself, from pit to railroad cars on the surface—a 1000-foot run.

The B. F. Goodrich cord belt "roughed" perfectly, eliminated two transfer points and reduced maintenance cost. It has already hauled 800,000 tons of vital iron ore, and the owners say it is good for at least 1,250,000 tons the first year and thousands more the next. Jobs like this, that have looked impossible, are being done every day by B. F. Goodrich industrial rubber products—the developments of constant research. That's why it pays to find out what improvements B. F. Goodrich has made in any rubber product you use. *The B. F. Goodrich Company, Industrial Products Division, Akron, Ohio.*

B.F. Goodrich

FIRST IN RUBBER

Reduce cylinder wear

MEMO from **CHIEF ENGINEER**

Order Cook's Graphitic Iron Piston Rings ###

AUTHORITIES differ as to the major cause of cylinder wear. But all are in agreement that the cost of cylinder wear together with the expense of cylinder and ring replacements in industrial size Diesels, constitute the major expense item on the maintenance sheet. Assuredly many variables enter the picture, but there is one thing certain—if piston rings could be dispensed with, little wear would occur. It is apparent then, that the piston rings to use are rings specially engineered to minimize wear. COOK has specialized in this all important phase of piston ring development for over 20 years, with the result that COOK'S GRAPHITIC IRON Piston Rings come as near to being frictionless as rings can be. If you do not have the full story of COOK'S GRAPHITIC IRON, write for special bulletin, but better still—to reduce the rate of cylinder wear in your engine, on your next requisition, instruct your buyer to order COOK'S GRAPHITIC IRON Piston Rings. If you need help do not hesitate to call on COOK'S engineers.

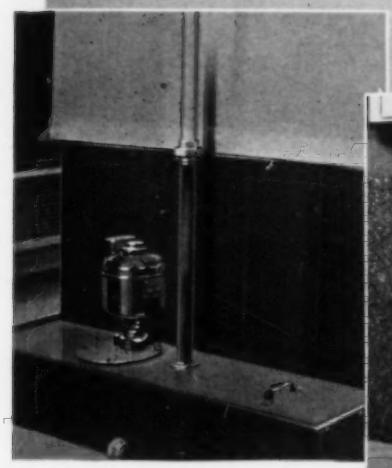
Sealing Pressures Since 1888

C. LEE COOK MANUFACTURING CO. INCORPORATED

LOUISVILLE, KY.

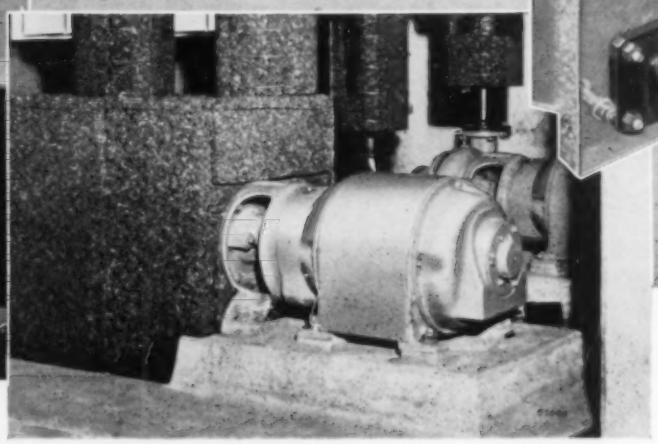
BALTIMORE • BOSTON • CHICAGO • CLEVELAND • HOUSTON • LOS ANGELES • MOBILE • NEW ORLEANS • NEW YORK • SAN FRANCISCO • TULSA

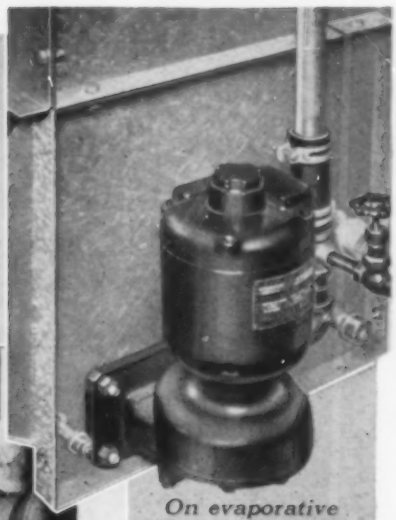
Motorpumps



Left—*On evaporative condenser.*

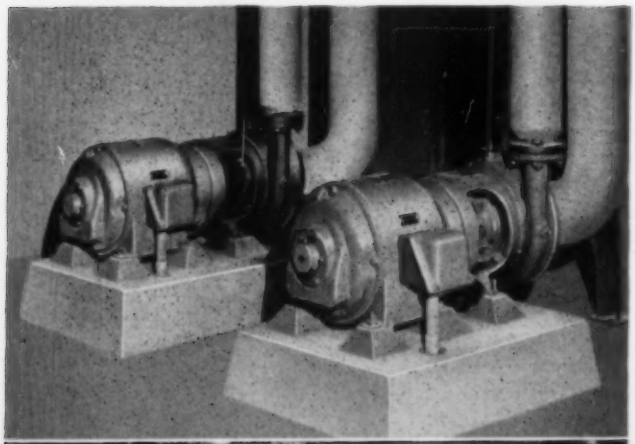
Below—*Circulating brine.*

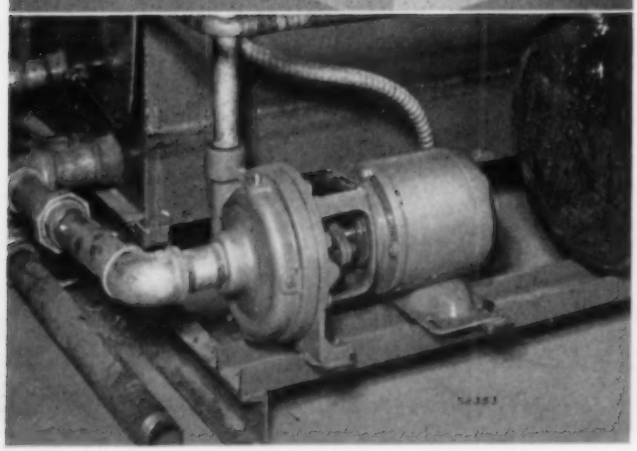




On evaporative condenser.

help REMAKE THE WEATHER





Above—*Circulating hot water.*

Left—*On humidifier.*

Motorpumps are ideal for air conditioning installations because (1) they are highly dependable, (2) they are efficient, (3) they are compact, (4) they are modern in appearance, and (5) repair parts are simple and readily available.

Motorpumps are built in a complete range of sizes for handling from 1 to 1800 gal. per min. against heads from 5 ft. to 600 ft.

Let our engineers give you complete information. Ingersoll-Rand Company, Cameron Pump Division, 11 Broadway, New York 4, N. Y.

Ingersoll-Rand

9-521

this breather
KEEPS OIL IN ITS PLACE
...another example of Air-Maze engineering
In ventilating crankcases and gearcases in engines, compressors, and other machines, oil can be lost by becoming entrained in air. Preventing this loss eliminates excessive oil consumption, nuisance and hazards. So for this purpose Air-Maze provides a line of breathers incorporating an oil-separating feature that returns the oil to the crankcase or housing.
You may never require a breather, but you can have *engineered filtration* in every Air-Maze filter. Whether your interest in filters applies to air conditioning, ventilating, compressors, blowers or engines, remember—"if it uses air, use AIR-MAZE".
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Representatives in Principal Cities. In Canada: Williams & Wilson, Ltd., Montreal, Quebec, Toronto, Windsor
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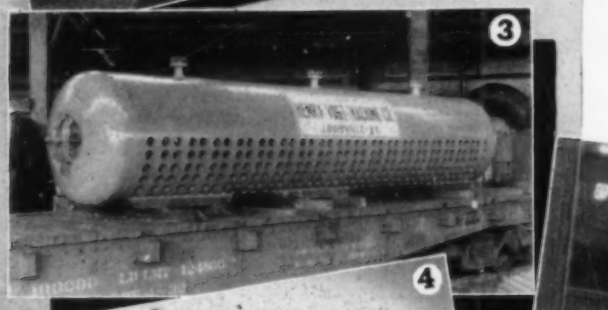
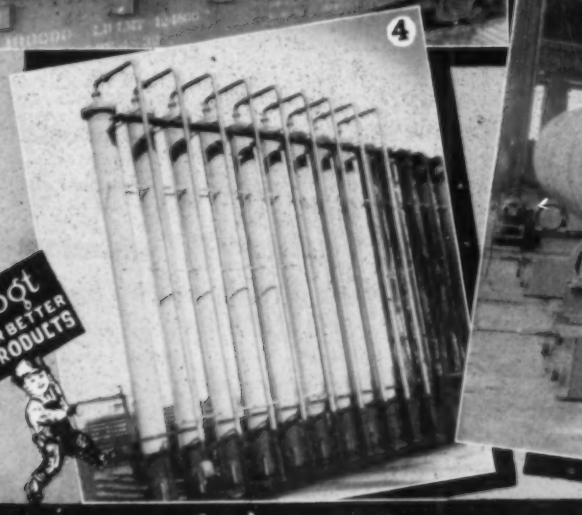
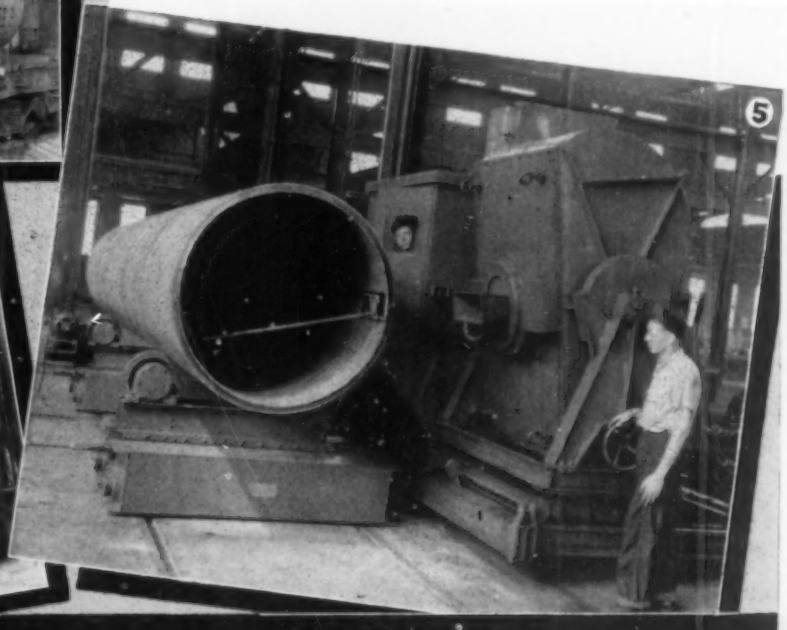
For further data on types and application of Air-Maze filters, send for Catalog AGC-144.
IF IT USES AIR...USE
AIR-MAZE
ENGINEERED AIR FILTRATION

A.P.I.—A.S.M.E. and A.S.M.E. CODES • CARBON STEEL AND SPECIAL STEEL

WELDED PRODUCTS *by* Vogt







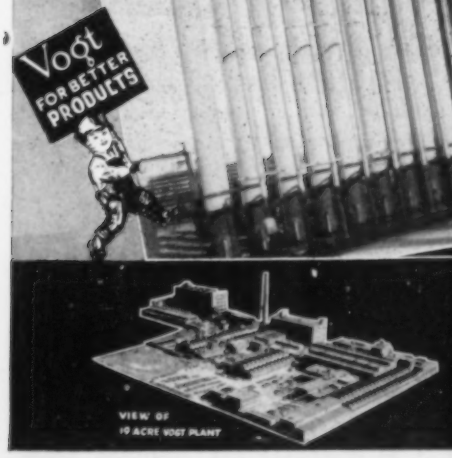
1 - 4′—0″ dia. x 7′—6″ dia. x 82′—5″ high Stabilizer Tower for a Texas Refinery. Fabricated to A.P.I.-A.S.M.E. Code, stress relieved and X-rayed. 250# working pressure.

2 - Heat Exchangers, for an Eastern Refinery, on the testing floor. Units have fusion welded Monel Metal shells and were built to customer's specifications.

3 - 48″ dia. x 22′—6″ long mud drum for a Vogt Water Tube Boiler designed to operate at 450# S.W.P. Fusion welded to A.S.M.E. Boiler Code.

4 - Battery of Absorption Columns in a Western Refinery. Units are 33″ dia. x 41′—0″ high and were stress relieved after welding.

5 - 400 KV Industrial X-ray unit in our plate welding department. Exographs of welded seams can be quickly made because of the special motor operated rolls and traveling carriages which are adjustable to vessels of any size.



HENRY VOGT MACHINE CO.
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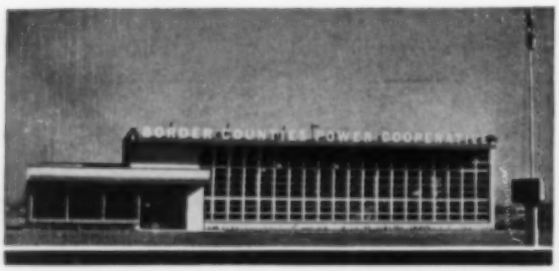
HOW TO PUT WASTE HEAT TO WORK

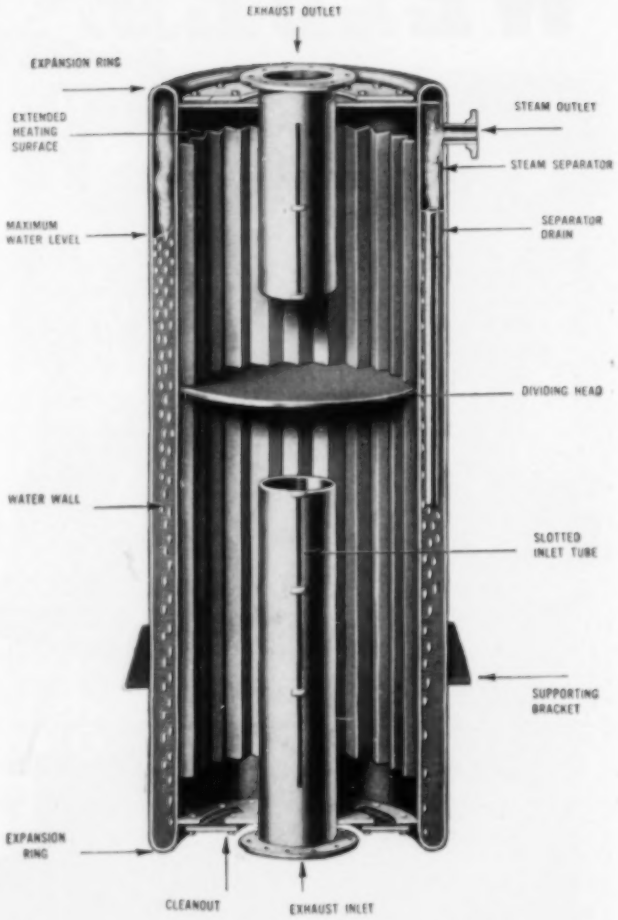
WITH MAXIM HEAT RECOVERY SILENCERS

Engine exhaust heat, all too often wasted, can be put to good and profitable use through Maxim Heat Recovery Silencers. With these specially constructed silencers extra steam or hot water for heating or processing operations is obtained *without extra fuel cost* as the heat source is simply engine exhaust heat. Thus in one unit effective exhaust silencing, spark arresting (where necessary) and heat recovery are combined for maximum operating efficiency. Such a saving, important to your balance sheet at any time, is doubly important where fuel supplies are difficult to obtain.

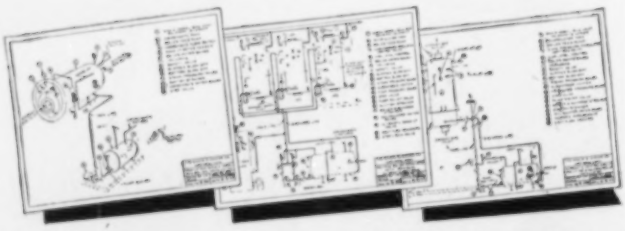
The power plant below located in northern Minnesota is heated entirely through the use of Maxim Heat Recovery Silencers.



For silencing, without the heat recovery feature, Maxim makes silencers for internal combustion engine exhaust or intake, steam engine exhaust, air compressor intake, vacuum pump discharge, blower intake and discharge, high velocity steam, air or gas discharge. Engine exhaust silencers available with or without spark arrestor. Bulletins on request.



PRACTICAL WORKING HOOK-UPS



The Maxim Engineering Department has prepared several drawings of typical Heat Recovery Silencer hook-ups. These are available with a detailed discussion of each hook-up. We will be giad to send them to you. Just ask for Dwgs. B-298, B-301, B-302 and B-303.

ARMY E NAVY

MAXIM

THE MAXIM SILENCER CO. • 85 HOMESTEAD AVE., HARTFORD, CONN.

$194*

AVERAGE COST OF COMPENSATION & MEDICAL EXPENSES FOR ALL ACCIDENTS OTHER THAN EYE ACCIDENTS

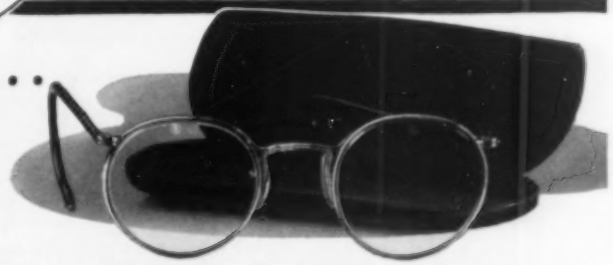
$343*

AVERAGE COST OF COMPENSATION & MEDICAL EXPENSES FOR EYE ACCIDENTS

Eye Accidents Cost the Most... Are Easy to Prevent

Note how much more costly eye accidents are. Yet, according to conservative estimates, 98% of all eye accidents are preventable. The wearing of Safety Goggles practically eliminates the danger from eye hazards. And the price of such protection is low . . . only about $1.50 per employee.

Your Safety Director can show you how an adequate eye protection program can materially *reduce your production costs*. Why not let him work out the details with an AO Safety Representative? There's an AO Branch Office in every large industrial center.



*Figures from bulletin published by Department of Labor and Industry, State of New York.

American Optical

COMPANY

SOUTHBRIDGE, MASSACHUSETTS

New

New

MODEL JA

50,000 R.P.M.

$29.75 in U.S.A.

NOTE:—Higher speeds at higher prices are available if supporting engineering data are submitted. Higher speeds are not recommended unless properly supervised.

Weight 12 ounces; Length 6¾ inches; Chuck Size ⅛ inch. Wheel Guard Removed for Better Illustration

KIPP

Featherweight

AIR GRINDER

The Model JA is new in design both inside and outside. In it are utilized fewer parts, and they are made of Magnesium and Aluminum for extreme featherweight lightness. The alloy steel shaft diameter is unusually large for sustained smooth and true operation. This means still longer wheel life and better grinding. The speed, as before, is governed at 50,000 R.P.M. and there are selected ball bearings, front and rear. The JA Featherweight is a distinct improvement over all models previously produced by Madison-Kipp, the originators of really high speed grinders.

The same low price, $29.75 in U.S.A., remains. It is a post-war design for which materials have been released early. The pre-announcement output was geared to expected demand. Deliveries will be made out of stock as long as possible.

by

MADISON-KIPP

MADISON-KIPP CORPORATION, 202 Waubesa St., Madison 4, Wis., U. S. A.

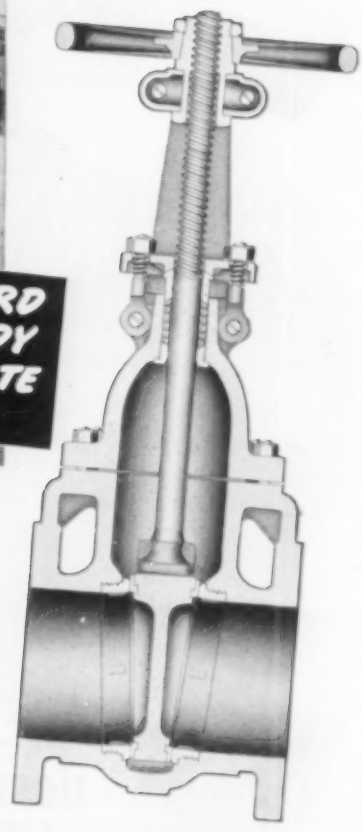
Sole Agent in England: Wm. Coulthard & Co., Ltd., Carlisle

For every part of Piping Systems depend on the Complete Crane Line

ONE SOURCE OF SUPPLY . . . ONE STANDARD OF QUALITY
ONE RESPONSIBILITY FOR ALL PARTS

Service Water Pumps in Electric Light and Power Plant.

Valves, fittings, pipe, fabricated assemblies, piping accessories—for any service—Crane supplies them all! You choose from the world's greatest line of piping materials—in brass, iron and steel. One source—your Crane Branch or Wholesaler supplies all your requirements. Uniform quality in all parts—and one responsibility for them—helps you get the best installation. Keep this *complete* Crane service in mind to simplify and speed deferred replacement work—and to get full advantage of 90 years' leadership in the piping equipment field.



SERVICE RECOMMENDATIONS: **Crane Standard Iron Body Wedge Gate Valves** with brass trim are recommended for steam, water and oil lines; all-iron valves for oil, gas and fluids that corrode brass. Made in OS&Y and Non-Rising Stem patterns.

Working Pressures

Size of Valve	Screwed or Flanged Valves		Hub End Valves
	Saturated Steam	Cold Water, Oil, or Gas, Non-Shock	Cold Water or Gas Non-Shock
2 to 12 in.	125 pounds	200 pounds	200 pounds
14 and 16 in.	125 pounds	150 pounds	150 pounds
18 to 24 in.	*	150 pounds	150 pounds

*For steam lines larger than 16-inch, Crane 150-pound Cast Steel Gate Valves are recommended.

CRANE CO., General Offices: 836 S. Michigan Ave., Chicago 5, Ill. · *Branches and Wholesalers Serving All Industrial Areas*

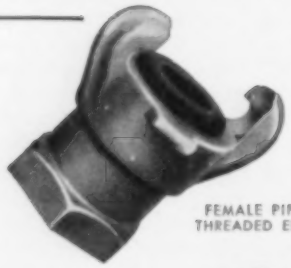
CRANE

90 YEARS OF PROGRESS 1855 1945

VALVES · FITTINGS · PIPE
PLUMBING · HEATING · PUMPS

ARE YOU PAYING FOR LOST PRESSURE?

MALE PIPE THREADED END



FEMALE PIPE THREADED END

HOSE END

DEAD END

Note rugged "Lip" or flange for firmer grip.

THREE-WAY

WHY TIE UP THOUSANDS OF DOLLARS

in compressors and other primary equipment and then find you're not getting pressure at full capacity? Direct power loss on air tools too often is caused by improper hose fittings . . . hose couplings that leak and cause loss of costly pressure.

For a quick-acting connection for manifold outlets on air compressors and other compressed air equipment, specify LE-HI Series 100, the Universal Type Hose Coupling that locks securely yet uncouples or couples by a twist of the wrist.

Available in malleable iron, Series 100 are proven under the most severe operating conditions to stand abuse without leaking or causing loss of pressure.

Check these LE-HI features and compare. Secure locking! Interchangeable! Easily coupled or uncoupled! Airtight! Tough!

Ask your distributor to show you the complete LE-HI line . . . a diversified line for industrial and construction hose applications.

Pat. No. 2132506

ANOTHER LE-HI "FIRST"

The New "Safety-Lock" Universal Type Series 150-M Hose Coupling

A positive yet simple locking device built into the hose coupling to prevent accidental uncoupling. Not just a gadget. It's a *patented lock* that *will not come apart unintentionally*. No more nails! No more cotter pins. No more make-shift locks.

Send today for LE-HI Catalog No. 644

HOSE ACCESSORIES COMPANY

2716 NORTH 17th STREET • PHILADELPHIA 32, PA.

SOLD ONLY THROUGH DISTRIBUTORS

A DIVERSIFIED LINE FOR INDUSTRIAL AND CONSTRUCTION HOSE APPLICATIONS

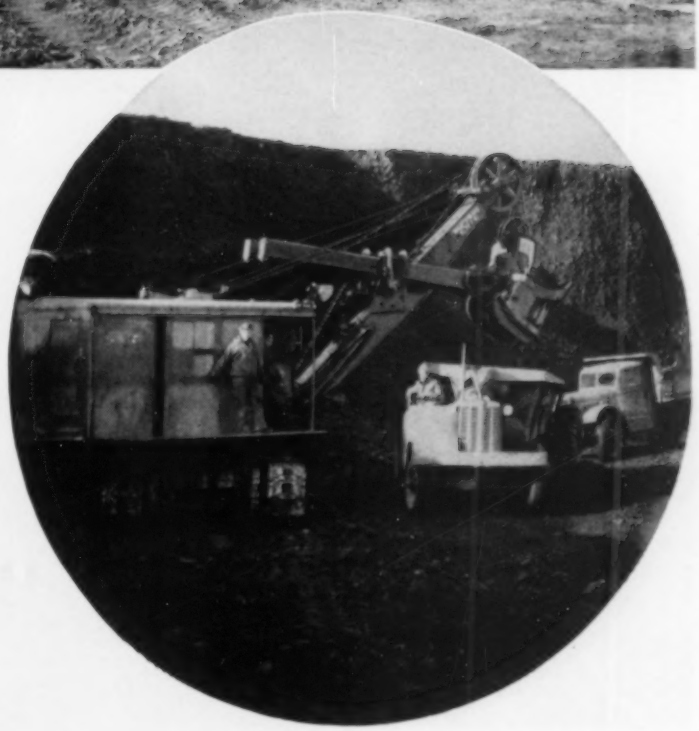
LE-HI

HIGH and LOW PRESSURE

HOSE COUPLINGS

Time-Tested RELIABILITY

At distant outposts or right here at home, the work of Bucyrus-Erie excavators proves again the value of superior design and manufacture in terms of dependability and big output. Today, when results count most, Bucyrus-Eries everywhere meet the wartime challenge with outstanding production.



Signal Corps Photo

Your faith in Bucyrus-Eries on your quarry and mining operations is reliance on time-tested machines with the **earned** reputation for "years ahead" performance. V-80

BUCYRUS ERIE

SOUTH MILWAUKEE, WISCONSIN

CONCRETE FACTS

about "Cushioned Air" Paving Breakers

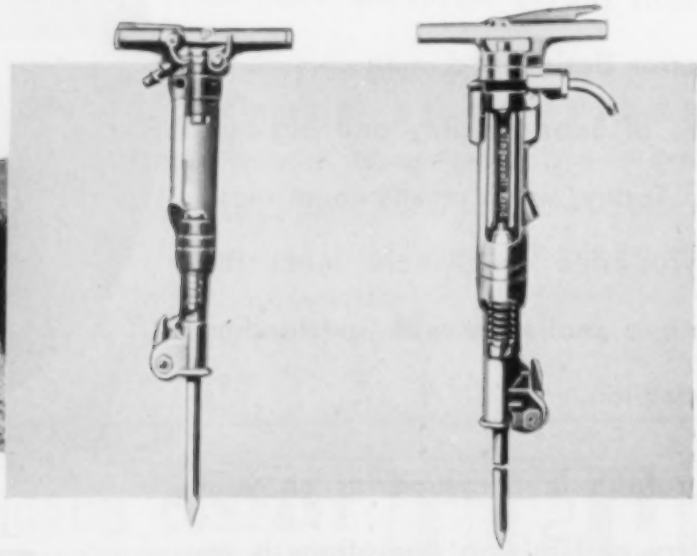
CC-60 and CC-80

POWER — The "Cushioned Air" principle absorbs the blow of the piston when the steel is not in contact with the work. Since the fronthead and parts do not take any of the shock of the piston blow, more power can be packed into these machines. Other advantages are:

LOW UPKEEP COSTS— When "Cushioned-Air" Paving Breakers are used, only the work and not the fronthead parts receives the full force of the piston blow. Breakage from the impact of such blows is eliminated.

EASIER HOLDING — "Cushioned-Air" does away with the shock which would otherwise be transmitted to the operator's hands and arms. This easy holding feature is of special advantage when working with high air pressures. Combine easy holding with the hard-hitting ability and low upkeep of these tools and the result is *more work done, less trouble, and lower costs.*

"Cushioned-Air" Paving Breakers are ideal for street repair and gas, water and sewer main and factory maintenance. The CC-80 shown above is breaking out an old pump foundation for refinery expansion.



"Cushioned-Air" Paving Breakers are available in two sizes — the 60-lb-class CC-60 is ideal for breaking brick and concrete, walls and floors where it is not feasible to use a heavier tool. The 80-lb-class CC-80 is widely used in contracting, quarrying, maintenance and demolition work. Pile driving frontheads for 2, 2½, and 3" wooden sheet piling are also available with this machine.

Ingersoll-Rand

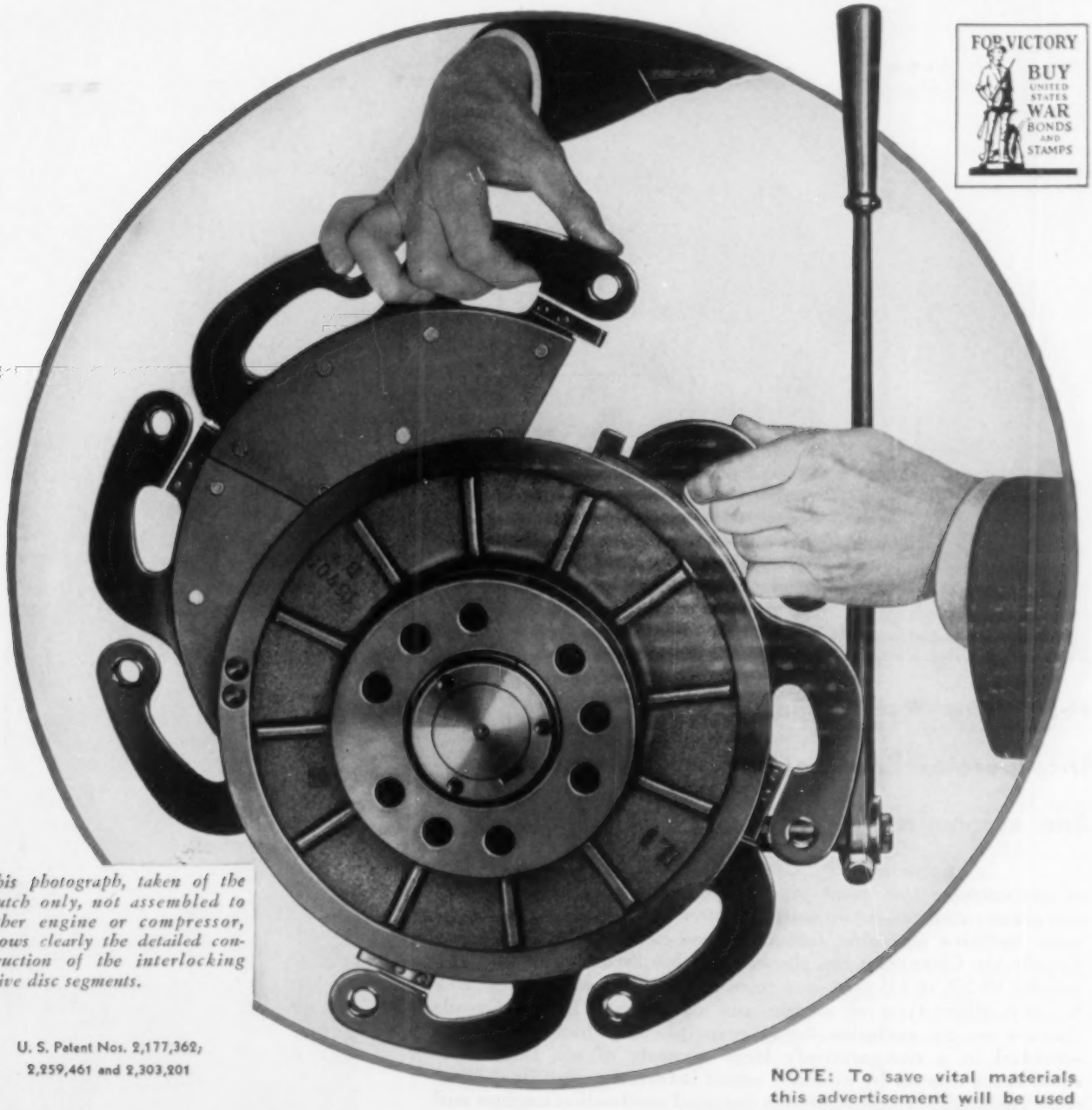
11 BROADWAY, NEW YORK 4, N. Y.

5-559

COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

FLEX-DISC CLUTCHES

Used on the entire line of I-R *Mobil-Air* Compressors, have a time proven drive disc with flexible fingers solidly bolted to the fly wheel. When the friction facings become worn these drive discs, which are quickly detachable in segments, may be removed and relined or replaced without disconnecting the engine from the compressor.



FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

This photograph, taken of the clutch only, not assembled to either engine or compressor, shows clearly the detailed construction of the interlocking drive disc segments.

U. S. Patent Nos. 2,177,362; 2,259,461 and 2,303,201

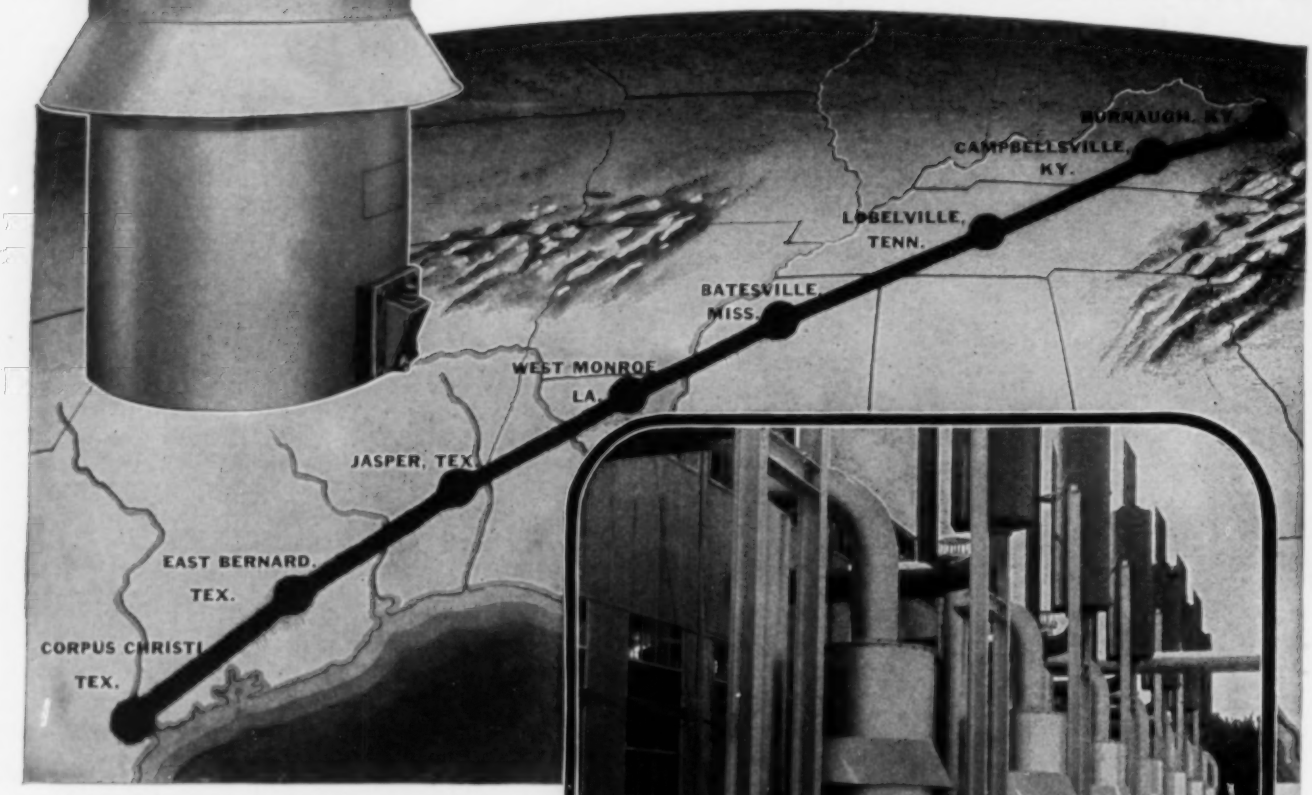
NOTE: To save vital materials this advertisement will be used for "the duration."

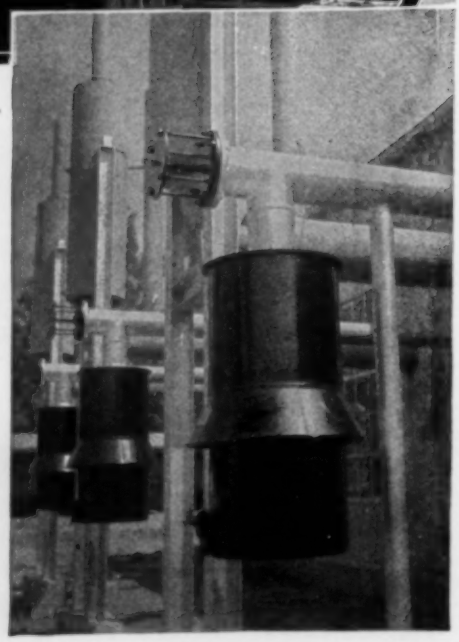
C. M. EASON, INDUSTRIAL CLUTCH CO.

Waukesha Wisconsin

CYCOILS ALL THE WAY!

TENNESSEE GAS AND TRANSMISSION CO.
Uses Cycoil Air Cleaners on <u>All</u> Its Engines





Huge Texas-West Virginia project incorporates "the best in pipe line economics"—and equipment

Approximately 25,000,000 of the 232,000,000 cubic feet of gas entering this great pipe line daily are used to drive its compressor and generator units . . . *after* being mixed with many more millions of cubic feet of Cycoil-cleaned air. American Cycoil Air Cleaners were chosen for this system because they remove 99.7% of all dust — a record of performance unequalled by any other type of engine and compressor filter. Cycoils operate on an exclusive 4-way principle in which the air is scrubbed in a comparatively large quantity of oil, then separated from this oil by cyclonic action before entering final filter cells. Investigate Cycoils for *your* internal combustion engines and compressors. They are available in a complete range of capacities. Write for Cycoil Bulletin No. 130-D.

AAF

AMERICAN AIR FILTER CO., INC.
Incorporated
402 Central Avenue Louisville 8, Kentucky
In Canada: Darling Brothers, Ltd., Montreal, P. Q.

A NEW *PLANETARY SYSTEM*... REVOLVING AROUND THE SOY BEAN

Blaw-Knox offers a complete service to the chemical and process industries. This includes everything from building pilot plants to producing equipment for full-scale production.

For the soy bean industry—as an example—Blaw-Knox has developed improved techniques and specially designed equipment. Blaw-Knox experience and creativeness, its engineering background, its complete facilities, are the basis for a reasonable assumption that Blaw-Knox can be of value to you if your business comes within its scope.

One way for you to find out how and to what extent Blaw-Knox can serve you, is to give us an opportunity for a mutual discussion. Out of that may come some important results.

BLAW-KNOX COMPANY

A PACEMAKER FOR AMERICAN INITIATIVE AND INGENUITY

2018 FARMERS BANK BLDG. PITTSBURGH, PA.

Five Blaw-Knox Plants have been awarded the Army-Navy "E" for war-production excellence

LEWIS FOUNDRY & MACHINE DIVISION,
Rolls and Rolling Mill Machinery

POWER PIPING DIVISION,
Prefabricated Piping Systems

COLUMBUS DIVISION,
Ordnance Matériel

SPECIAL ORDNANCE DIVISION,
Bofors Anti-Aircraft Gun Mounts and Mechanisms

BLAW-KNOX DIVISION,
Chemical & Process Plants & Equipment, Construction Equipment, Steel Plant Equipment, Radio & Transmission Towers . . . General Industrial Products

PITTSBURGH ROLLS DIVISION,
Rolls for Steel and Non-Ferrous Rolling Mills

UNION STEEL CASTINGS DIVISION,
Steel and Alloy Castings

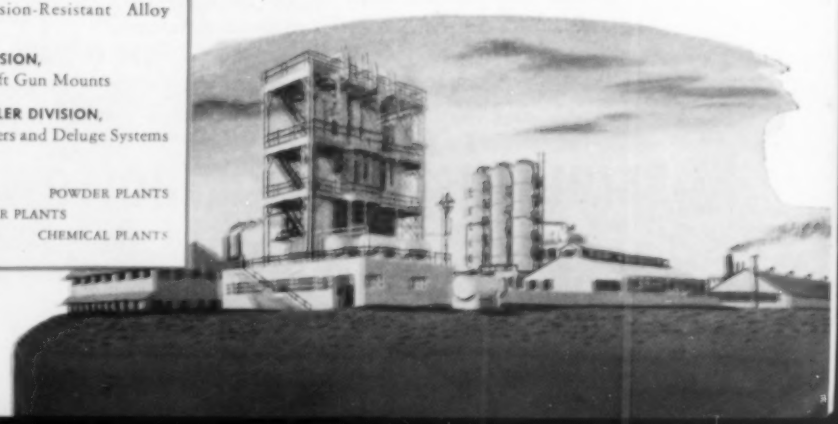
NATIONAL ALLOY STEEL DIVISION,
Heat and Corrosion-Resistant Alloy Castings

MARTINS FERRY DIVISION,
Bofors Anti-Aircraft Gun Mounts

BLAW-KNOX SPRINKLER DIVISION,
Automatic Sprinklers and Deluge Systems

A FEW VICTORY PRODUCTS

ANTI-AIRCRAFT GUN MOUNTS · GUN SLIDES · LANDING BARGES · POWDER PLANTS
PIPING FOR NAVAL VESSELS · SYNTHETIC RUBBER PLANTS
CAST ARMOR FOR TANKS & NAVAL CONSTRUCTION · CHEMICAL PLANTS



HI, BILL, HAVEN'T HEARD YOU YELLIN' ABOUT DRILL STEEL LATELY.
NOTHIN' TO BEEF ABOUT, CAP, SINCE WE GOT THIS BETHLEHEM STOCK IN HERE

CAP: Notice we been gettin' nice footage. Pretty good drill steel, huh?

BILL: Yeah. They call it Hollow Superior. Good name for it. Best steel I've ever used.

CAP: How come?

BILL: Well, for one thing, it's tough. I can tell it's tough the minute I start cuttin' 'er down to length. Look at that fracture. Tells you a lot.

CAP: You haven't wanted repair parts for the sharpener lately. Drill steel responsible?

BILL: More 'n you'd think, Cap. This steel forges easy. Always true to size, and the hole's where it ought to be. Carbon seems to be right, too.

CAP: Anyway, something's sure speeded things up around here. Haven't had to ask for extra help lately. Maybe the steel *does* make a difference.

BILL: *Maybe?* Listen, Cap. This Bethlehem stock runs a better hardness under heat-treatment. Always runs the same, too—and it gives me what I want when I quench it. That's why it stays in action longer.

CAP: You sound like a salesman.

BILL: Look, mister. This steel's good enough to sell itself. And by the way, Jones has been havin' trouble with the stuff he's been usin' over at No. 2. Better tell him to get himself some of this Bethlehem Superior.

Here's a tip for *you*, too. For more footage and lower costs, ask your Purchasing Department for BETHLEHEM SUPERIOR HOLLOW DRILL STEEL.

★ BETHLEHEM SUPERIOR HOLLOW DRILL STEEL ★

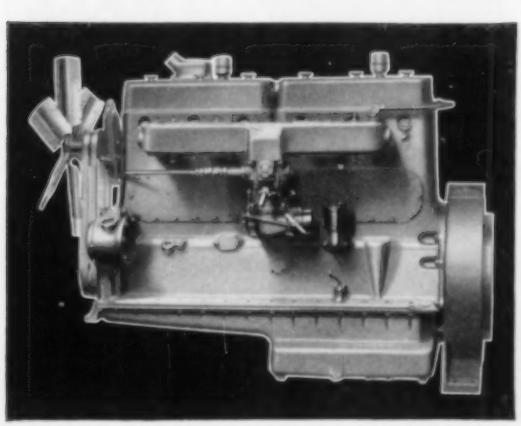
BETHLEHEM STEEL ★

SNOWED IN ?

NO!

...not with

WAUKESHA POWER BEHIND THE PLOW



Neither snow in big drifts ten or twelve feet high, nor packed down almost rock-hard, can stop a Snow King Rotary Plow from clearing the highways. With its Waukesha Super Duty Six it's powered to push right through—cutting a clean, full-width swath —shooting the snow in a steady stream to either side of the road. Why do the plow makers, Imperial Machine Co., Minneapolis, use this Model 6-WAK Waukesha Engine? Because it has every modern design and construction feature . . . for maximum power and easier, more economical maintenance. Burns gasoline or butane. Six cylinders, 6¼ in. bore, 6½ in. stroke, 1197 cu. in. displacement. It's *the* engine for the super trucks and buses, oil field machinery, pumps, generators and other mobile industrial equipment of tomorrow. Get Bulletin 1138.

WAUKESHA MOTOR COMPANY, WAUKESHA, WIS. • NEW YORK • TULSA • LOS ANGELES

MORE POWER FOR VICTORY

WAUKESHA ENGINES

LIGHT... but STURDY

If you want to see how lightness can be combined with utmost sturdiness in a Portable Pop or Relief Valve, just look at and then study the FARRIS design. You'll find the bowl-shaped body generously proportioned, and the springs extra large . . . yet with no unnecessary weight anywhere on the valve. In addition, like all FARRIS Safety and Relief Valves, you'll find this a truly precision built valve of highest quality in every detail.

Built in sizes from ½ in. to 2½ in. and for pressures to 250 lb. steam. Write for full information without obligation . . . you'll find it well worth while to become acquainted with this outstanding value in Pop Valves.

FARRIS ENGINEERING CO.
354 Commercial Ave.
Palisades Park, N. J.

Farris
RELIEF POP VALVES

New Model A-1 *Pur-O-fier*

For Compressed Air

Positive purification of air lines is assured with this new Model A-1 Pur-O-fier designed to eliminate free moisture, oil and foreign matter in small compressed air systems. It operates with from 1 to 5 cubic feet of air and for intermittent operations is extremely sensitive to the slightest movement of air. Weighing only 1¼ lbs., this new unit is just 3⅛" in diameter by 5⁹⁄₁₆" deep including plastic, transparent entrainment sump. Model A-1 Pur-O-fier requires no maintenance.

Drain valve permits easy and quick draining of the sump. Pur-O-fier uses positive, centrifugal action as a medium for purification and can be used for air-operated instrument controls, air-operated gauges of the precision and checking type, and air-operated cleaning devices of many types. This unit will operate effectively from 1 to 75 P.S.I. Write for bulletin No. 11 giving complete details.

Patent applied for

Write for New Bulletin No. 11 giving complete specifications and applications

BIRD-WHITE COMPANY
3120 WEST LAKE STREET
CHICAGO, ILLINOIS

BUY ALL THREE FOR ONLY $6.00

or

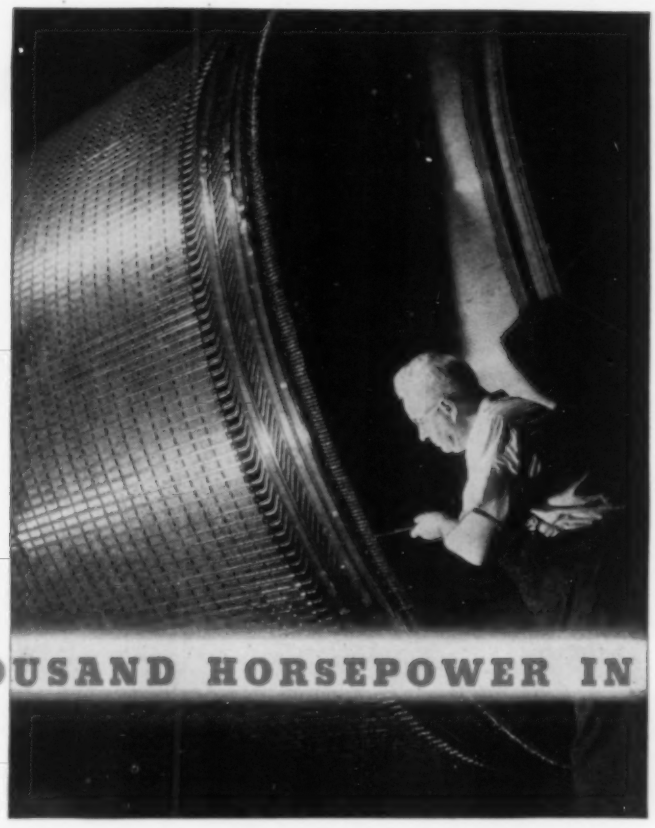
Any COMBINATION at PROPORTIONATE SAVINGS

COMPRESSED AIR MAGAZINE, 942 Morris Street, Phillipsburg, New Jersey.
Please send me:

- ☐ Compressed Air Data, Cameron Hydraulic Data and Cameron Pump Operators' Data ..... All three for $6.00.
- ☐ Compressed Air Data and Cameron Hydraulic Data .. Both books for $5.00.
- ☐ Cameron Hydraulic Data and Cameron Pump Operators' Data Both books for $4.50.
- ☐ Compressed Air Data and Cameron Pump Operators' Data Both books for $4.50.
- ☐ Enclosed is (money order) (check) for $.....) ☐ Send books C.O.D.

I understand that the books will be sent me postpaid, and that they may be returned within 10 days if not satisfactory.

Name .....
Company .....
Street No. .....
City .....State .....Country .....



SEVEN THOUSAND HORSEPOWER IN ONE MOTOR

To drive a mill that rolls 120-inch steel plate, up to 2 inches in thickness, takes a motor with plenty of "guts".

This one has it. The rotor alone weighs 100 tons, whirls at a speed of more than 80 times a minute. More than 50,000 feet of copper wire are contained in its windings.

This 7,000 hp giant, one of the largest motors built by Westinghouse for the steel industry, is now helping to turn out armor plate for America's fighting forces.

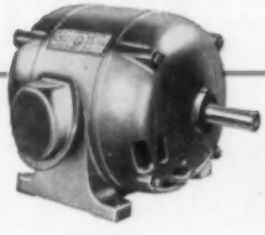
The chances are you'll never need a motor like this. Yet the kind of engineering skill that goes into such specialized motor jobs is back of every Westinghouse motor you buy—special or standard.

Whether you need a fractional horsepower motor or one delivering thousands of horsepower, Westinghouse experience can help you solve your drive problem quickly—with a motor exactly fitted to the job. Westinghouse Electric & Mfg. Co., East Pittsburgh, Penna.

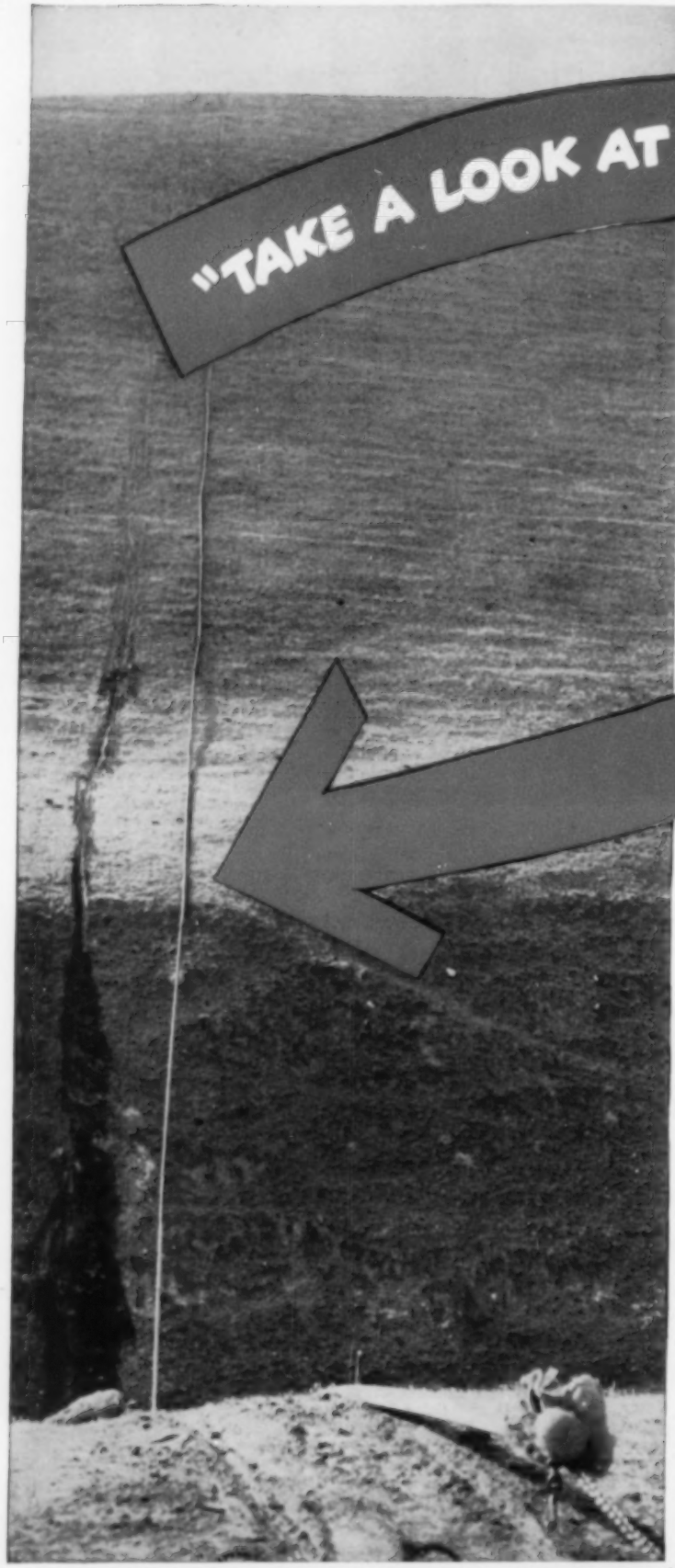
J-21301

Westinghouse motors

PLANTS IN 25 CITIES... OFFICES EVERYWHERE



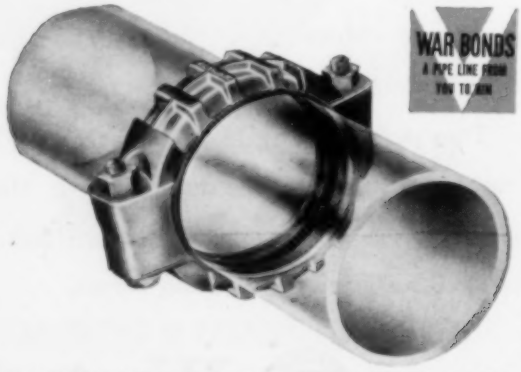
This is only one of the many Westinghouse general purpose motors available in standard and special enclosures. Features include choice of sealed-sleeve or ball bearings; Tuffernell insulation; dynamically balanced rotor; rigid one-piece frame; die-cast rotor; radio-frequency tested insulation.



"TAKE A LOOK AT THIS—BROTHER!"

One thousand-foot lengths of joined pipe were dragged over hilly terrain at a single clip! Here is how it was done . . . The Western Oil Fields Supply Company moved 15,000 feet of 3″ pipe, towing it in 1,000-foot lengths! . . . that means that as much as *50 sections of pipe remained coupled as they were dragged up and down hills, across ravines.* The strain on these couplings was terrific . . . strain from pull, plus strain from sag, as the line was drawn over a wide ravine . . . What couplings have the strength and flexibility to stand up against such a load? . . . *The exclusive Victaulic Coupling.*

The Western Oil Fields Supply Company states . . . "Our special ability is laying pipe across difficult terrain. We have over 50 miles of 2″ and 3″ pipe rented throughout California, laid across desert-like country, over treeless plains, up and down rugged hills. On every one of these pipelines we use Victaulic Couplings exclusively." Take a look at the advantages of the one and only genuine Victaulic Coupling, and you'll see why. We'll gladly send further details. Write Victaulic Company of America, 30 Rockefeller Plaza, New York 20, N. Y.



VICTAULIC

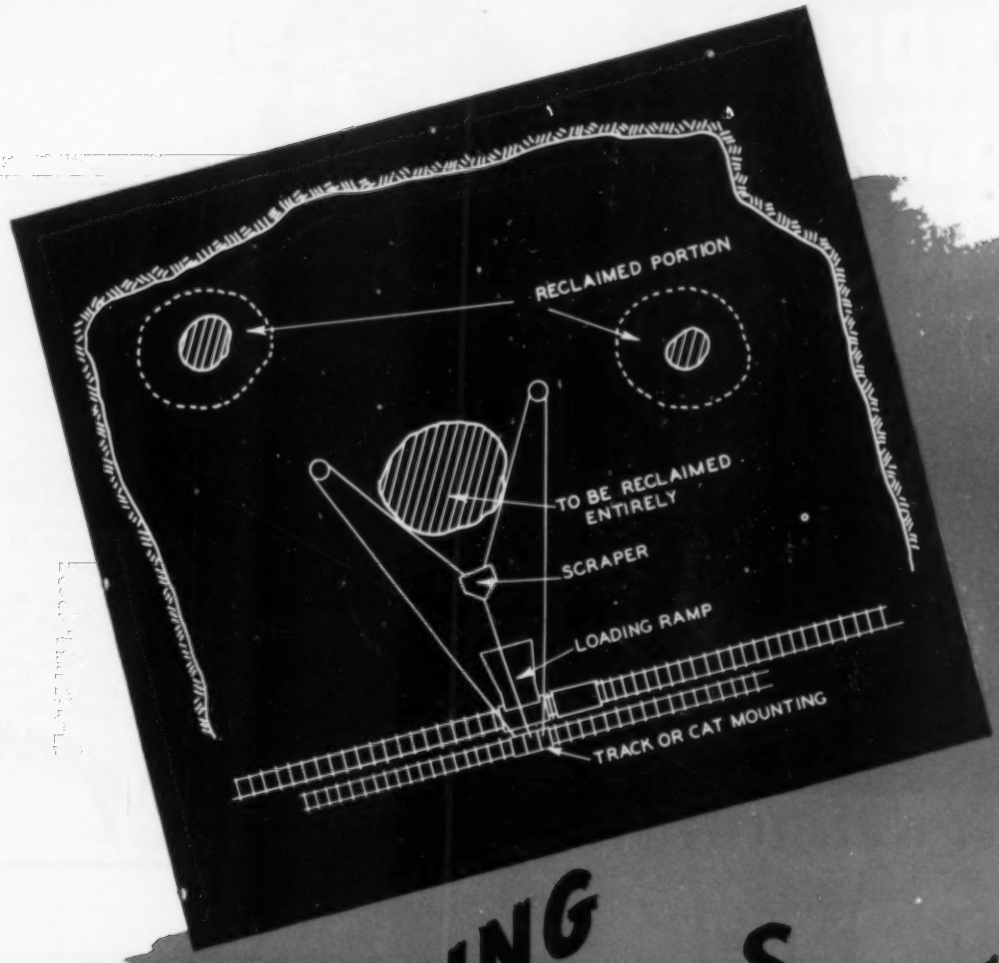
Reg. U. S. Pat. Off.

SELF-ALIGNING PIPE COUPLINGS AND FULL-FLOW FITTINGS

1,000 feet of pipe joined by Victaulic Couplings, being dragged down a hill and across a ravine by light tractor-powered winch in high Sierra foothills.

Copyright 1945 by Victaulic Co. of America

OIL MINING MARINE MUNICIPAL INDUSTRIAL



RECLAIMING PILLARS SAFELY

After an ore body has been mined by the room-and-pillar system, at some later time certain pillars or sections of pillars are often reclaimed. This practice is used especially where the ore content is high.

Reclaiming pillars obviously is not the safest kind of work, even when the utmost safety precautions are observed. Scraper hoists are without a doubt the most popular piece of equipment used for reclaiming pillars. The only time it is necessary for a miner to enter the working area is when the sheave blocks are hung. From then on, the scraper hoist and operator located at a safe distance from the pillars remove the broken ore with a minimum of danger. The use of scraper hoists permits a quick recovery of the pillars before the back takes weight. The sheave block and scraper are the only equipment that is out in the area where the pillar is being removed.

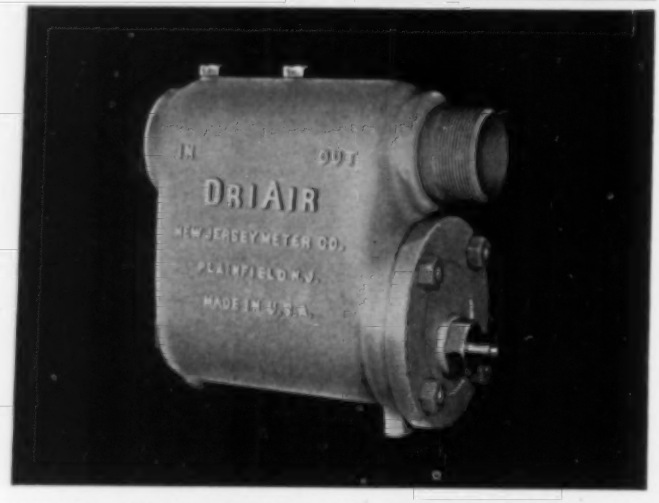
Remember that regardless of the metal mining system—somewhere, some place, scraper hoists are being used. Scraper hoists combine three operations. (1) The scraper is *self* loading. (2) It transports the ore. (3) It automatically dumps its load. We build a size and type for every kind of mucking. Should you desire to discuss the application of these hoists to your system, we will gladly have one of our experienced scraper hoist engineers pay you a visit. Send for a copy of our Slusher Hoist Catalog, Form 2379-B.

Ingersoll-Rand

11 Broadway, New York 4, N. Y.

16-534

DEPENDABLE PNEUMATIC SERVICE



WHEN EQUIPMENT IS PROTECTED BY

DRIAIR

A COMPLETE SELF-CONTAINED UNIT

DriAir may be installed by suspending it from the piping without any other support.

A typical installation showing DriAir standing on the floor next to the wall.

● The answer to many problems which arise in various applications of compressed air, DriAir speeds production by separating and automatically ejecting the condensed water and oil from the air. DriAir collects dirt and rust from the air lines and delivers clean dry air to the tools, thus reducing wear and prolonging their life. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent. Copy of Bulletin DA fully describing the operation of DriAir sent on request; write today.

NEW JERSEY METER COMPANY

PLAINFIELD, NEW JERSEY

BUILT TO TAKE IT!

Limber as a Lariat
STRONG as STEEL

Norgren Synthetic Hose Assemblies are built of the finest material and constructed to take it; from heat, cold, solvents and vibration.

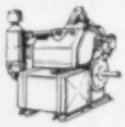
Meet the full requirements for high and low, hydraulic or pneumatic pressure lines. Permanent machined couplings for high pressures and re-usable couplings for low pressures. Available, with male or union couplings, in a range of sizes, any length.

Send your inquiry, including I.D., length of hose and thread requirements, to C. A. Norgren Co., 220 Santa Fe Dr., Denver 9, Colorado.

Norgren

PRECISION-GROUND CAMSHAFTS

another "HIDDEN VALUE" in all WISCONSIN Air-Cooled ENGINES



The "Camomatic" is another of those more-than-human machines that help to put heavy-duty serviceability and smooth-running efficiency into every Wisconsin Engine.

This machine automatically rough-grinds (and subsequently "smooth-finishes") each and every cam for every Wisconsin Air-Cooled Engine. The grinding wheel finishes cam contour with absolute precision and uniformity. Every camshaft for a given size engine, is exactly like all the other camshafts for all the other engines of that size.

This is another of those features you *don't* "see" . . . but it performs an important service for you *on the job, on your equipment.*

Most H.P. per pound

WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MORE THAN EVER YOU NEED *Securityflex* (BUNA)

...the Twin Parallel cable with these exclusive construction advantages

This cross-section shows Anaconda's twin parallel Securityflex cable with self-contained ground wire. This special cable has only slightly increased diameter, so that usual lengths may be handled on standard conductor reels. It offers a simple, convenient method for grounding loaders, conveyors, cutters, etc.

for example...

1. *Special D-shaped insulation* developed by Anaconda cable engineers. Prevents twisting. Impossible for one conductor to ride over the other and cause failures.
2. *Time-saving Breaker Strip* to separate the two conductors. Connections and splices can be made with greatest speed and ease.
3. Maximum flexibility . . . thanks to Anaconda Herringbone compensating construction.
4. Rugged Seine Twine reinforcement webbing for greater strength and to prevent tearing of jacket.
5. Buna jacket instead of rubber, as formerly —due to the wartime elimination of rubber in all mining cable. This fact, of course, *makes Securityflex construction features even more important than ever.* 44247

ANACONDA WIRE & CABLE COMPANY
Subsidiary of Anaconda Copper Mining Company
General Offices: 25 Broadway, New York 4
Chicago Office: 20 North Wacker Drive 6
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ANACONDA

Anaconda Wire & Cable Co.

BEST BEARING FEATURES OF BOTH BABBITT AND BRONZE

. . . WITHOUT THE DISADVANTAGES OF EITHER, AND POSSESSING ADVANTAGES OVER BOTH

BEARIUM METAL

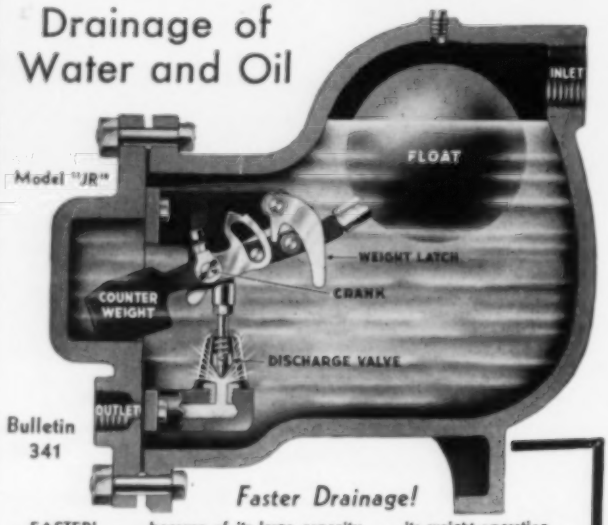
★ Does not seize the shaft
★ Will not score
★ Prevents bearing failures
★ Increases bearing life

CASTINGS • MACHINED BUSHINGS • CORED AND SOLID BAR STOCK • CENTERLESS-GROUND RODS

Write for full information on this amazing Bearing Alloy

BEARIUM METALS CORP.
270 STATE STREET, ROCHESTER 4, N. Y.

A Compact Compressed-Air Trap
FOR
AUTOMATIC
Drainage of Water and Oil

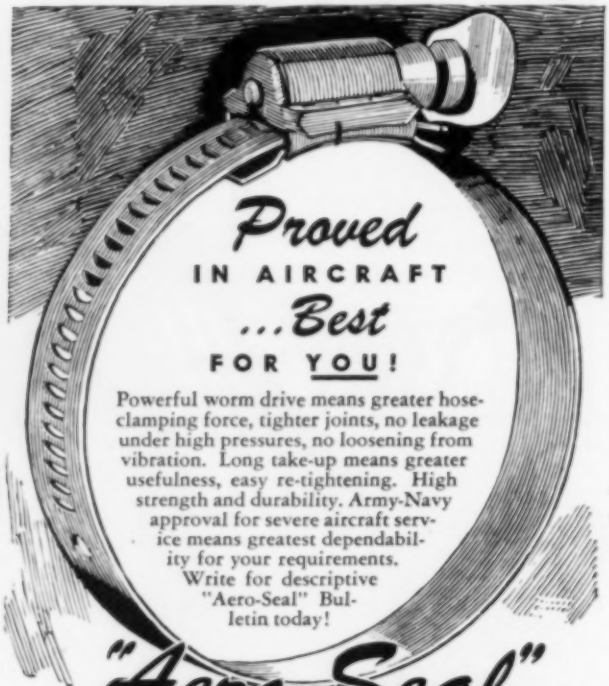


Bulletin 341

Faster Drainage!

FASTER! . . . because of its large capacity. . . its weight-operation, giving full positive action . . . its rapid intermittent opening and closing. Welded stainless steel float. Water-sealed discharge valve.

W. H. NICHOLSON & CO.
180 OREGON ST., WILKES-BARRE, PA.
Valves ★ Traps ★ Steam Specialties

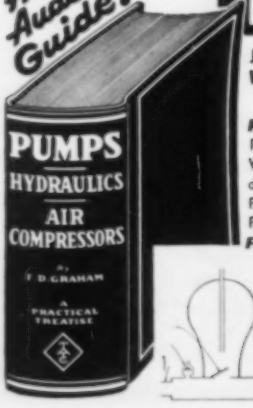


Proved
IN AIRCRAFT
...Best
FOR YOU!

Powerful worm drive means greater hose-clamping force, tighter joints, no leakage under high pressures, no loosening from vibration. Long take-up means greater usefulness, easy re-tightening. High strength and durability. Army-Navy approval for severe aircraft service means greatest dependability for your requirements. Write for descriptive "Aero-Seal" Bulletin today!

"Aero-Seal"
HOSE CLAMPS
AIRCRAFT STANDARD PARTS CO., 1771 19th AVE., ROCKFORD, ILL.

An Audel Guide!

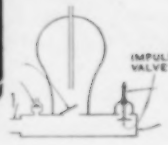


PUMPS-HYDRAULICS-AIR COMPRESSORS

JUST OUT! 3 BOOKS IN ONE—OVER 1650 PAGES, 1654 ILLUSTRATIONS, WITH QUESTIONS AND ANSWERS. COMPLETE PRACTICAL CONCISE INFORMATION FOR ALL ENGINEERS AND OPERATORS.

***PART 1*—PUMPS—850 Pages:** All types—Centrifugal—Rotary—Reciprocating Pumps: Their Theory, Construction, Operation and Calculations. Air and Vacuum Chambers—Power Pumps—Air Pumps—Jet Condensers—Surface Condensers—Condenser Auxiliaries—Condenser Operation—Calculations—Cooling Ponds—Cooling Towers—Water Supply—Hydraulic Rams—Special Service Pumps—Automotive Fire Pumps—Dredges—Codes. 942 Illustrations.

***PART 2*—HYDRAULICS—320 Pages:** Hydraulic Physics—Drives—Machine Control—Accumulators—Elevators—Hydraulic Airplane Control—Automobile Brakes—Shock Absorbers—Presses—Turbines. Many new uses explained. 310 Illustrations.



***PART 3*—AIR COMPRESSORS—406 Pages:** Compression of Air—Compressor Classification—Parts, Types—Inter and After Coolers—Regulating Devices—Installation—Lubrication—Operation—Maintenance—Blowers—Super-Chargers—Pneumatic Hand Tools—Ready Reference Index and Tables. 402 Illustrations.

Free Examination

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$4 COMPLETE
PAY ONLY **$1** A MO.

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Send postpaid AUDELS PUMPS, HYDRAULICS, AIR COMPRESSORS ($4). If I decide to keep it, I will send you $1 within 7 days; then remit $1 monthly until purchase price of $4 is paid. Otherwise, I will return it promptly.

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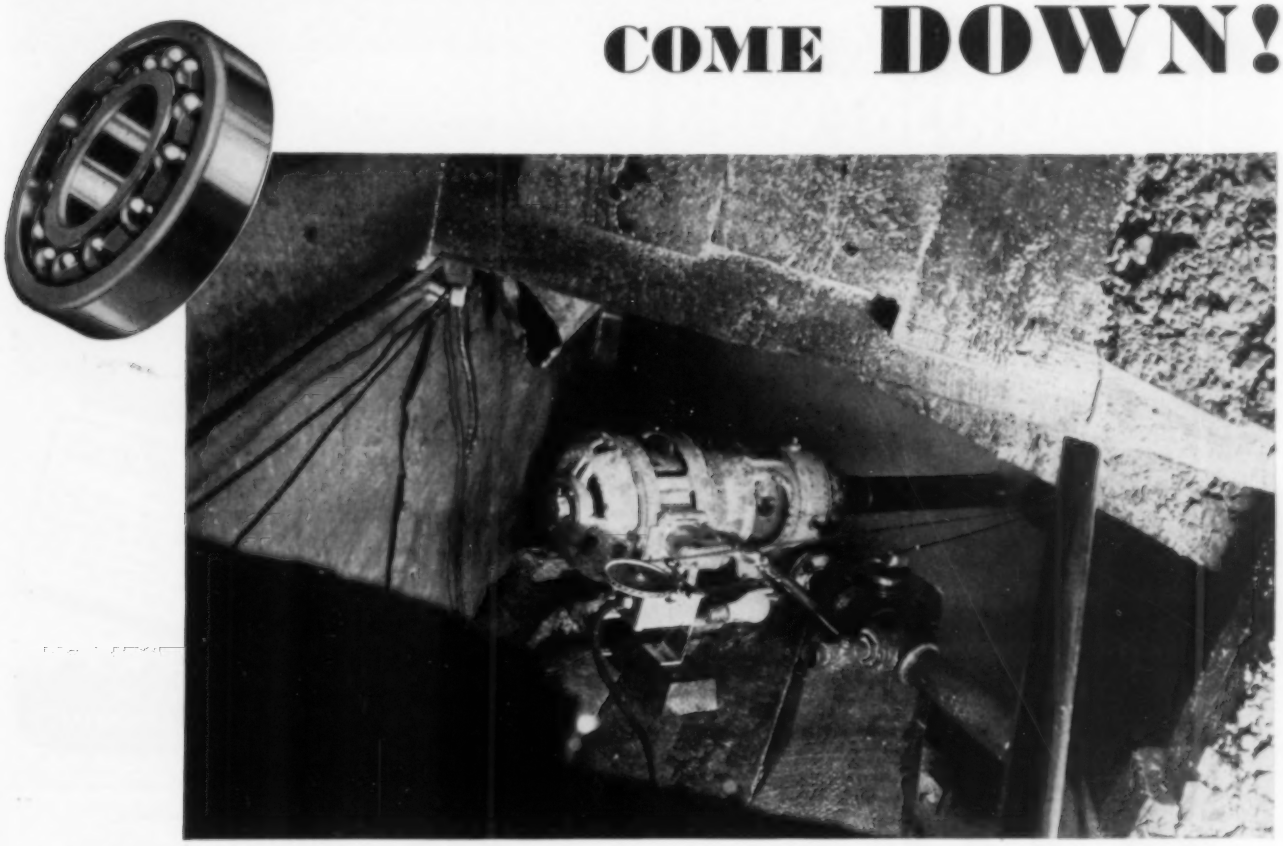
Address .....
Occupation .....
Employed by 211

PUMPING COSTS COME DOWN!

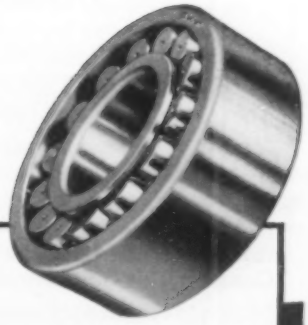


● *Built by* INGERSOLL-RAND CO.

There are three good reasons why SKF Bearings on this Cameron Motorpump cut costs: 1. Profit-slicing shutdown periods are eliminated. 2. Wear is reduced to a minimum since the bearings provide a rigid shaft that gives smooth, vibrationless operation. 3. Elimination of shaft whipping reduces stuffing box maintenance. They are the three reasons that have made SKF's preferred for years on Motorpumps with capacities ranging from 5 to 1000 gallons per minute against heads up to 240 feet single-stage and 500 feet two-stage, sizes from ¼ to 40 h.p. Give any machine an SKF, and you give it Performance.

5737

SKF INDUSTRIES, INC., PHILADELPHIA 34, PA.



Pioneering in practically all industries, SKF produces ball and roller bearings of all types and sizes, from ⅝" to 59" O.D.

SKF
PUTS THE RIGHT BEARING IN THE RIGHT PLACE

SKF
BALL AND ROLLER BEARINGS

Wherever wire rope is fastened
STANDARDIZE
on Genuine
CROSBY CLIPS
with the Red U-Bolt

A safe, lasting and easy-to-put-on clip for every size of rope from 1/8-inch to 4-inch.

Sold by leading distributors everywhere

AMERICAN HOIST & DERRICK CO.
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THE GENUINE *Crosby Clip*
WHEREVER WIRE ROPE IS FASTENED

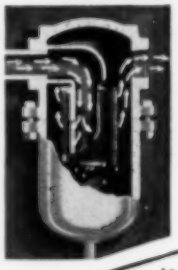
MAKES *Compressed Air* COME CLEAN

THE JOHNSON GAST *2-way* SEPARATOR

WATER, dirt and oil in compressed air lines can be a big source of trouble and expense—causing imperfect results, and deteriorating air hoses and equipment rapidly.

The Johnson-Gast Separator is the simplest way to make your compressed air come clean. It takes out more than 99% of all troublesome foreign elements, because it employs *both* of the accepted principles of separation—expansion and change of direction. The illustration shows its simple, sturdy construction. It can be used with equal efficiency on steam lines also.

When moisture in the air is vaporized by heat generated during compression, the Johnson-Gast Aftercooler is used to condense all vapor so the Separator can remove it. Where every final trace of oil must be removed—as in paint spraying—the Johnson-Gast Oil Absorber is also used.



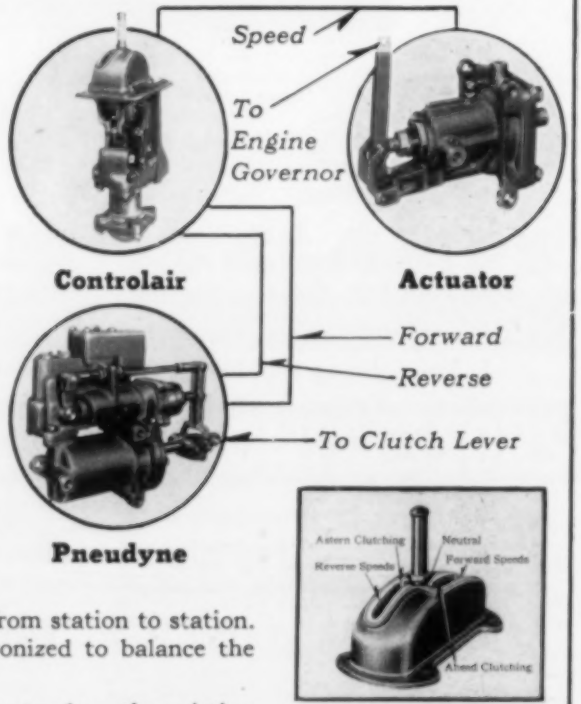
1. Air first expands, precipitating most of moisture.
2. "Thousand Baffles," labyrinth of wire mesh, changes flow direction — captures remaining water and dirt.

Write for bulletin showing sizes and capacities of the complete Johnson-Gast line of separating devices.

THE JOHNSON CORPORATION
830 Wood Street, Three Rivers, Mich.

JOHNSON-GAST
SEPARATORS • AFTERCOOLERS • OIL ABSORBERS

W•A•B PNEUMATIC CONTROL SYSTEMS *for* DIESEL ENGINES



W•A•B Pneumatic Control Systems are winning new advocates through their superb performance of functions from a remote control station.

On non-reversing Diesel engines, clutch shifting and engine speed are controlled from a single lever. A Pneudyne, on the housing of the directional clutch, shifts the clutch lever, and an Actuator on the engine positions the speed lever of the engine governor as directed by the lever position of the Controlair at the control station.

Multiple engines are controlled from multiple control levers. Dual control stations may be used, with control transfer from station to station. Multiple engines driving the same power shaft are synchronized to balance the engine load.

On direct reversing engines, pneumatic controls are super-imposed on the existing manual controls or built into the engine design.

Position Diagram of Controlair

WESTINGHOUSE AIR BRAKE CO.

INDUSTRIAL DIVISION - WILMERDING, PA.

"This is the most complete Manual on Belting I ever saw . . .

yet it has only 56 pages!"

All in this one handy 56-page booklet, you'll find...

How to pick the right leather belt for the job — a conveniently-organized section on what to expect from various tannages . . . tables on how to figure belt dimensions from horsepower and speed of motor . . . further aids on figuring drives not covered by tables . . . recommendations on belt thickness and pulley size, classified by types of machine drives.

How to select between Modern Group Drive and Automatic Tension Drive (pivoted motor base).

How to select between Multiple-V-Belt and Flat Leather Belt for Automatic Tension Drive.

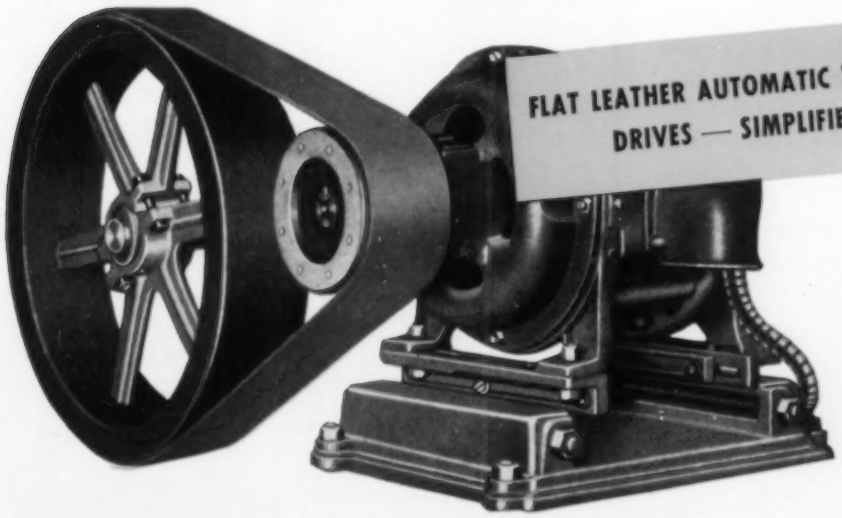
How to figure Flat Leather Automatic Tension Drives — useful short cuts.

How to figure prices — table on prices, another on pivoted motor base prices.

How to install your flat leather belt.

How to make your belts deliver more power and last longer.

This manual has been published for *your* convenience. Use the coupon—receive your copy by return mail. No obligation.



Make sure you know the opportunities for reduced maintenance, longer life, greater efficiency offered by the Flat Leather Automatic Tension Drive. Explained in the Manual — along with information on other types of drives.

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HOW DID THAT OLD "HAS BEEN" GET GOIN' AGAIN? I THOUGHT SHE'D BEEN JUNKED
SHE HAD GARLOCK PACKING INSTALLED AND GOT HER OLD JOB BACK

CHEVRON Packing

Yes, Garlock CHEVRON automatic action packing has proved itself on thousands of applications in general industry throughout the country. The unique hinge-like, cross-sectional design allows the packing to expand and contract—*the greater the pressure, the tighter it packs.* You can always depend on CHEVRON for superior performance.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Limited, Montreal, Que.

Garlock

There Is No Compressed Air Condition So Bad In Any Factory That We Cannot Correct and Completely Remedy

WATER removed from AIRLINES AUTOMATICALLY with the MURPHY SEPARATOR

SIZES ½" TO 4" PIPE

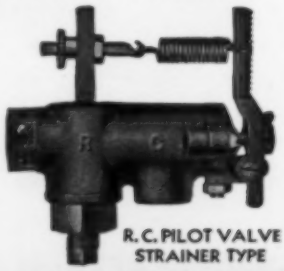
Literature and Prices on request

RESULTS - - - GUARANTEED
NO ABSORBENTS - NO CHEMICALS
AFTERCOOLERS - - - SPRAYERS

JAS. A. MURPHY & CO.
HAMILTON, OHIO

R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.



R. C. PILOT VALVE
STRAINER TYPE

R. CONRADER CO.
1207 FRENCH STREET - ERIE, PA.
PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders

More inside information on POWELL VALVES

This small size 200-pound "White Star" Bronze Gate Valve looks very much like the same type of valve in other makes. But back of it—back of every Powell Valve—is nearly a century of specializing in the manufacture of Dependable valves for Industry.

The result of this Powell "know how" is a line of valves ruggedly built to give long, uninterrupted service and require minimum maintenance. These are reasons why Powell Valves are the choice of leading industrial plants throughout the nation.

The complete Powell Line includes all types of valves (Globes, Angles, Gates, Checks, Y's, etc.) not only in bronze, iron and steel but also in a wide variety of pure metals and special alloys to meet every requirement for corrosion resistance (Catalogs on request).

And if you have any unusual flow control problems, Powell Engineers will be glad to make a careful study of your requirements and design special valves to meet the conditions.

The Wm. Powell Co.

Dependable Valves Since 1846

Cincinnati 22, Ohio

This valve, especially adapted for use in lines where pressure drop is undesirable, is giving long, dependable service in the compressed air field.

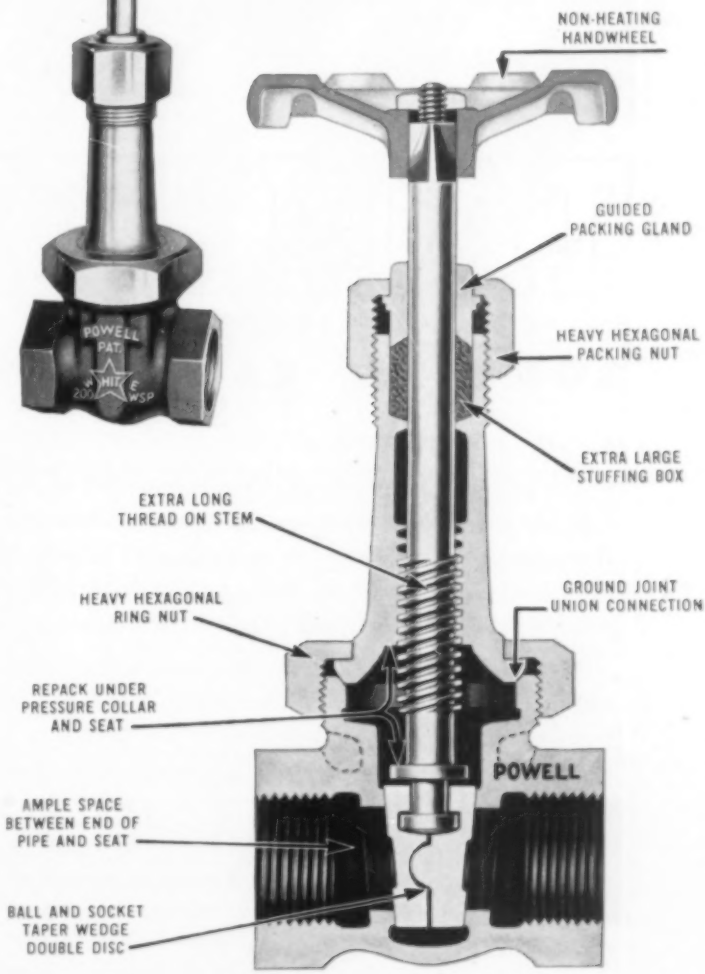

NON-HEATING HANDWHEEL
GUIDED PACKING GLAND
HEAVY HEXAGONAL PACKING NUT
EXTRA LARGE STUFFING BOX
EXTRA LONG THREAD ON STEM
HEAVY HEXAGONAL RING NUT
GROUND JOINT UNION CONNECTION
REPACK UNDER PRESSURE COLLAR AND SEAT
POWELL
AMPLE SPACE BETWEEN END OF PIPE AND SEAT
BALL AND SOCKET TAPER WEDGE DOUBLE DISC

Fig. 375
BRONZE "WHITE STAR" GATE VALVE

POWELL VALVES

TAMPTITE MAKES

LOADING EASY, SIMPLE, EFFECTIVE

● The power of the dynamite is concentrated in the bore hole for maximum blasting effectiveness when you use Hercules patented Tamptite cartridges. Tamptite shells slide easily into the bore hole, and expand with slight pressure of the tamping rod to fill the hole tightly.

Tamptite cartridges conserve man-hours, eliminate completely the slitting of cartridges and loose, spilled powder around the working area. They give you better breakage, faster handling of materials, and, thus, increased output.

When ordering your favorite Hercules mining explosives, be sure to specify . . . "In Tamptite cartridges."

With Tamptite cartridges, the bore hole is loaded in the usual manner. No wasted time slitting cartridges.

The tamping rod packs the charge snugly in the hole, leaving practically no air space around the dynamite.

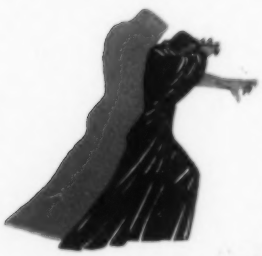
Continue inserting Tamptite cartridges and compressing them until the desired loading is achieved. This compact charge means better breakage, speedier mucking, a faster mining cycle.

HERCULES
EXPLOSIVES

XR-51

HERCULES POWDER COMPANY INCORPORATED 930 KING STREET, WILMINGTON 99, DELAWARE

At Last!—a line of products to PREVENT RUST!



FOR YEARS American Industry has paid tribute to demon rust to the tune of $1,000,000,000 a year. Rusting of lubricated surfaces has been "put up with" as a necessary evil. Shell scientists and engineers, working with steam turbine manufacturers, did the "impossible" . . . developed a rust-preventive turbine oil.

Using the wealth of knowledge gained by developing and perfecting this oil, Shell's Research Laboratories then focused their efforts on developing a similar line of rust-preventive oils for general industrial purposes. The result is the new Shell Tellus Oils for machine lubrication and the new Shell Ensis Rust Preventives for coating metals.

The New Shell Tellus Oils are not designed to *remove* rust. They will not eliminate all existing rusting conditions that may be present in your machines. But where moisture is a factor, the new Shell Tellus Oils, because of the special rust-inhibiting qualities built into them, afford unequaled protection against the formation of rust . . . and without the sacrifice of other valuable characteristics. They form a protective film that coats the metal, making it highly resistant to water and moisture. They also have superior oxidation stability.

The New Shell Ensis Rust Preventives cover a complete line of oils, coatings and compounds. They are available in a number of grades, designed to give protection against the dangers of exposure, which range from the extreme effects of rain and snow during outdoor storage, to the mild humidity conditions encountered in the factory between machining operations. The protective coatings formed by Shell Ensis Rust Preventives graduate from the extremely thin, transparent oil films that need not be removed, to the heavy, abrasion-resistant coatings which will withstand severe weathering conditions over long periods of time.

Call in the Shell man now! After a thorough study of your operation he will recommend the Rust Preventive Product best suited to your specific conditions. Write, wire or phone Shell Oil Co., Inc., 50 W. 50th St., New York 20, N. Y., or 100 Bush St., San Francisco 6, Calif.

SHELL ENSIS Rust Preventive Coatings

SHELL TELLUS Rust Preventive Lubricating Oils

SHELL

A dependable source of Air Power
TIMKEN BEARING EQUIPPED

The truck-mounted compressor shown in the photograph, like various other types of compressors manufactured by the Ingersoll-Rand Company, is equipped with Timken Tapered Roller Bearings on the crank shaft. Thus it gives the user anti-friction advantages in full, because Timken Bearings not only reduce friction to the verge of elimination; they safely carry radial loads, thrust loads and both together in any combination; and hold moving parts in constant alignment under all conditions of operation. Adding the efficiency and endurance of Timken Bearings to the soundness of Ingersoll-Rand design and construction, produces compressors that are able to stand up for longer periods under continuous capacity service with minimum attention for lubrication and maintenance. This is a time-conserving factor that every construction contractor can appreciate. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN

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TAPERED ROLLER BEARINGS